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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

New Restoration of Hadrosaurian Dinosaur

C. M. Sternberg

Department of the Secretary of State

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
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C.M. STERNBERG

Several restorations of hadrosaurian dinosaurs have been published in poses that, in my opinion, are not justified. The final decision in this matter must rest with the evidence shown in the fossil.

From the delta deposits of the Oldman and Edmonton formations, exposed along Red Deer River in Alberta, many splendidly preserved, articulated skeletons of hadrosaurs have been collected. These represent both subfamilies, Hadrosaurinae and Lambeosaurinae, or what are popularly called flat-headed and hooded duck-billed dinosaurs.

All evidence seems to show that the hadrosaurs lived in bayous and river floodplains and escaped from the large carnivorous dinosaurs by swimming out of their reach. The hadrosaur had webbed feet and a long, high, narrow tail, and its skin was much too thin to protect it against the sharp teeth of the large carnivores. The structure of the skeleton of these large carnivores, which at this stage of development was completely bipedal, suggests that, although they were much swifter on land than the hadrosaurs, they could not go into deep water. Some of the hadrosaurs may have been attacked on land or in shallow water; however they reached deep water before they died. In such cases, the carcas , which would settle to the bottom or drift into a backwash, would be covered with mud and sand before any distortion or misplacement would take place. Many of these skeletons came to rest on their side and were buried, completely encased in their skin, with not a bone misplaced, except that the whole skeleton was laterally compressed by the weight of overlying sediments. In some cases, sand and mud penetrated the skin and filled the body cavity, as the flesh decayed, and thus the complete natural outline was preserved.

The so-called mummy dinosaurs in the American Museum of Natural History and in the Senckenberg Museum might illustrate this latter type of preservation.

In some cases the carcass settled in the bottom; in other cases it was washed up on a sandbar or mudflat and torn apart by the flesh-eaters, and later the disarticulated skeleton was covered by sediments. In some cases so completely did the sand and mud fill all cavities that distortion was prevented and the exact shape of even such thin bones as the premaxillae and the nasals of the hooded hadrosaurs was preserved. It was from such a specimen that I was able to get the correct shape of the hood, with the elongated, winding air passages, of *Corythosaurus excavatus* (6 – Plate I). If the skull were buried on its side, with no filling in the cavities, the thin bones of the hood would be flattened so as to suggest a cockscomb-like structure, as is shown in many early restorations.

Besides these skeletons found in their complete state, numerous other carcasses had been torn apart by the carnivorous dinosaurs and crocodiles, and their bones scattered through the strata or deposited in great bone beds where thousands of individual bones were piled together at the height of wave or flood action, just as driftwood is washed up on beaches.

The very favourable conditions for the preservation of these skeletons enable us to get much information about their structure which would be difficult to ascertain under other conditions.

In 1916 Barnum Brown described and illustrated a naturally articulated, complete skeleton of a hooded hadrosaur *(Corythosaurus casuarius)* from Alberta (1). In this paper Brown showed a restoration of *Corythosaurus* in a swimming pose. I regard this pose as almost perfect; it is the upright pose on land that I object to. Numerous other articulated skeletons of hadrosaurs have been collected from the Oldman and Edmonton formations along Red Deer River in Alberta. Many of these have been illustrated by Parks, for those in the Royal Ontario Museum (4 and 5), and by Lull and Wright in their Hadrosaurian Dinosaurs of North America (2). The National Museum of Canada (previously the Museum of the Geological Survey) has collected about a dozen more or less complete, articulated skeletons, most of which have not been illustrated.

The hadrosaur skeletons were so strongly held together, especially the vertebral column, by well-defined articular surfaces and ossified tendons along the neural spines, that there was little or no distortion, except lateral crushing, if the skeleton was buried soon after death. In all these articulated skeletons, from about the seventh thoracic vertebra back through the proximal two-thirds of the tail, the top of the neural spines is remarkably straight. This is due largely to the rigid support given by the ossified tendons on either side of the neural spines, a condition which would prevent

any arching of the back. Forward from about the seventh thoracic, the vertebrae turn sharply downward to the base of the neck, thus lowering the fore-part of the body so that the shorter fore limbs would reach the ground. This feature is very noticeable in all naturally articulated skeletons. (If this were the result of shrinkage of axial muscles, the reverse would be true.) From its base the neck turns sharply upward and unites with the head at about right angles to the line of the lower jaw. Since the occipital condyle is fixed and points directly downward, it would be impossible to articulate the skull straight ahead of the neck, as is sometimes shown. In a quadrupedal pose, the contour of the tail, back, neck, and limbs is quite normal, and bones articulate properly. As the neck is rather long and flexible in articulated skeletons, the head may be too far forward or backward. In Brown's skeleton of *Corythosaurus* (1, Figure 2) the head was too far back, as shown by a break in the contact of the basic cervicals. In the skeleton of *Anatosaurus edmontoni* in the National Museum of Canada, which was mounted in 1913, the head was thrown forward and downward near the fore limbs, and, as palaeontologists were not then aware of the arching of the neck, the head was straightened out.

In all the naturally articulated skeletons, the femora point forward and downward, never backward and downward. If the animal normally assumed an upright pose, surely some of the skeletons would show the femora pointing backward or at least directly downward. With the femur pointing forward and downward, the head of the bone fits in the acetabulum of the illium which is well supported by the fused acetabular bar. If the animal assumed an upright pose, the main thrust of the head of the femur would bear against the union of the pubic peduncle and the pubis. This is a weak joint. The pubic peduncle in the hadrosaurs was much lighter than that in the large theropods which were bipedal though not necessarily upright. The well-developed articulating surface on the posterior part of the distal condyles suggests that the knee was strongly flexed. In an upright pose, these surfaces would never come into use. If the hadrosaur assumed an upright pose, the tibia and fibula would, of necessity, point directly down from the femur because of the stiff forward ten feet of the tail. In such a position the distal end of the tibia would not articulate properly with the foot.

Lull and Wright illustrate a fore limb pointing almost straight down from the glenoid cavity of the scapula, but the head of the humerus is not in the glenoid cavity (2, Figure 20). If properly articulated, the humerus stands almost horizontal, and the ulna and radius stand vertical. In this position all the bones articulate perfectly. This is the same general arrangement as in the ceratopsians, ankylosaurs, thescelosaurs, and probably many other dinosaurs. The two flat-headed hadrosaurs, known as dinosaur mummies, which the Sternbergs collected from the Lance formation of Wyoming, showed this arrangement. The one in the American Museum of

Natural History was preserved on its back, and the one in the Senckenberg Museum apparently had been bogged in quicksand. As mentioned above, most articulated skeletons had been buried on their side, and the humerus would have dropped down flat before burial.

In making my model I have tried to keep the proper proportions of the various parts and have used as a basis my type of *Lambeosaurus clavinitialis* (6). The model was made one-eighteenth natural size. The over-all length of the fore limb is 65½ inches, and that of the hind limb, measured in the same way, is 112 inches. The fore limbs are of much lighter construction than the hind limbs, but they had much less weight to carry.

CONCLUSIONS

It is my opinion that the hadrosaurs seldom left the water; probably when wading in moderately deep water, the front part of the body was buoyed up, and only the hind limbs were used for support; but when in shallow water or on land they were quadrupedal.

References

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   (1916) *Corythosaurus casuarius* skeleton, musculature and epidermis. Am. Mus. Nat. Hist. Bull. 35, p. 709-716, Fig. 1-16.
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   (1942) Hadrosaurian dinosaurs of North America. Geol. Soc. America, Special Paper 40.
3. Ostrom, John H.
   (1964) A reconstruction of the Paleoecology of hadrosaurian dinosaurs. Am. J. of Science, Vol. 262, p. 975–997.
4. Parks, W.A.
   (1935) New species of trachodont dinosaurs. Univ. of Toronto Studies, Geol. Ser. No. 37, p. 1-45, Pl. I-VIII.
5. ———
   (1935) Dinosaurs in The Royal Ontario Museum. Univ. of Toronto Quart. 4, p. 179-200.
6. Sternberg, C.M.
   (1935) Hooded hadrosaurs of the Belly River series of the Upper Cretaceous. Nat. Mus. Canada, Bull. 77, p. 1-37.

Figure 1. Skeleton of *Lambeosaurus* sp. in the rock east of Manyberries, Alberta. Much of this skeleton was destroyed by erosion before discovery, but the position of the vertebral column and the articulation of the head and limbs are typical of the naturally articulated hadrosaurian skeleton (Neg. No. 83381).

Figure 2. *Lambeosaurus* skeleton in typical quadrupedal pose. Model by C.M. Sternberg (Neg. No. J9714).

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

TYPE SPECIMENS OF FISHES IN THE NATIONAL MUSEUM OF CANADA

With Brief Historical Notes

D. E. McAllister

Department of the Secretary of State

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TYPE SPECIMENS OF FISHES IN THE NATIONAL MUSEUM OF CANADA
With Brief Historical Notes

D.E. McAllister

Introduction

This paper lists the type specimens of fishes deposited in the National Museum of Canada. Some of the specimens, formerly in other institutions, are now in the National Museum of Canada. Others were deposited in the National Museum when it was known as the Victoria Memorial Museum. Attention is drawn to these and other type specimens. This is part of the museum's responsibility (a recommendation of the International Code of Zoological Nomenclature, 1958). Permanent care is offered for types ichthyologists may wish to deposit.

History of National Museum Fish Collection

A brief history of the National Museum of Canada fish collection is given here. A history of the whole museum from 1910 to 1960 is provided by Russell (1961) and a history of Canadian ichthyology by Dymond (1964).

The history of the National Museum fish collection may be divided into an early period (prior to 1958) and a recent period. Prior to 1900 some collections of fishes were made by field personnel of the Geological Survey of Canada, such as Robert Bell, G.M. Dawson, A.P. Low, W. Spreadborough, and C.H. Young. The oldest fish specimens, two *Typhlichthys subterraneous*, were collected in August 1863. Naturalist John Macoun of the Geological Survey published a list of western fishes (Macoun, 1882). Bean and Weed (1920) published on material collected in Vancouver Island by Young and Spreadborough in 1909; a type from this study was deposited in the U.S. National Museum.

During the Canadian Arctic Expedition, 1913-18, the growth of the fish collection accelerated. Mr. Frits Johansen joined the museum staff (1913-18) as assistant naturalist to Dr. R.M. Anderson (see Porsild and Bousfield, 1959, for biography). On this expedition, he actively collected fishes, along with insects, marine invertebrates, and plants, and also made detailed habitat notes. After leaving the National Museum he wrote a manuscript on the fishes of Arctic Canada for publication as a museum report on the expedition. It was, however, not completed in time for inclusion in volume 6 (pub. 1922), for which it was intended. The greater portion of a third copy of this manuscript is in the National Museum of Canada. It

consists of several hundred typed foolscap pages with corrections written in and additional pages of corrections and additions not intercollated. It covers in full detail habitat, life-history, description, literature, and station-by-station accounts of each species. This draft appears to have been completed about 1926 or 1927 and was mailed back to the museum in 1934. It was never itself published, although parts have been incorporated in recent publications by Walters 1953, etc. (see below).

During this period, material such as that of the Canadian Arctic Expedition was exchanged with other institutions, among them the United States National Museum, the British Museum, the American Museum of Natural History, and the Copenhagen Museum. About a dozen collections were recatalogued from the Ottawa Fishery Museum (see Lloyd, 1939; Halkett, 1906; for notes on this museum).

It was not until the 28th of March 1914 that a catalogue of fish specimens was begun. Entries in the fish catalogue were first made by Claude Johnson, then by Dr. R.M. Anderson. The catalogue was continued sporadically, the following numbers being used:

1 to 157	up to August 1925 (no. 114-123 incl. omitted)
176 to 191	up to July 1925
201 to 213	up to February 1926
226 to 243	up to July 1925
1001 to 1189	up to December 1916

The intervening numbers were not used. The last series was only partly catalogued; the entries were pencilled in, and the identifications, if any, were by common name; even type specimens were not indicated. In this period, 1914-26, less than 400 catalogue numbers were used; the total number of catalogued specimens was something over 500. The specimens were preserved in ground-glass stoppered bottles or in large earthenware crocks.

After 1926 no further catalogue numbers were used. Up to 1951 over 2,000 additional specimens accumulated. Andrew Halkett, Philip Cox, and J.D. Soper contributed material.

In the period 1952 to 1958 the fish collections were cared for by the museum herpetologist, Dr. J.S. Bleakney. He wrote one paper on fishes (Bleakney, 1954). During this period the collection was added to more rapidly, and an additional 2,000 specimens were accumulated. Assisting Dr. Bleakney in this regard were Mr. S.D. MacDonald, who made valuable collections of arctic material, and Dr. E.L. Bousfield, invertebrate zoologist, who contributed material from the Atlantic and Pacific coasts. The specimens were stored on several tiers of shelving in the cold-storage vault. On August 1, 1958, the writer joined the staff as curator of ichthyology and herpetology. The curatorship of herpetology was assumed by Mr. F.R. Cook when he joined the staff on May 26, 1960. A new cataloguing system for fishes was instituted in 1958 whereby ecological data could be

Fig. 1. Fibreglass-lined plywood tank 8 feet long for large specimens such as sharks.

Fig. 2. Adjustable steel shelving on which the National Museum fish collection is presently stored.

kept, and a geographical index was provided. The previously catalogued collections were recatalogued. Specimens were changed to 45 per cent isopropyl alcohol in modern glassware. Large specimens are kept in 3-foot stainless steel boxes or an 8-foot fibreglass-lined plywood tank (Fig. 1). Collections were moved to a room on the fourth floor; when this became too crowded, they were moved to room 7 on adjustable steel shelving, Fig. 2, in the basement, the adjacent room 9 being used to process incoming ichthyological and herpetological collections. An X-ray machine is now available for osteological studies.

In 1952 Vladimir Walters examined Frits Johansen's manuscript and a portion of his collections, and published an 18-page paper on the fishes of the Canadian Arctic Expedition (Walters, 1953). Previous to this, Hildebrand (1948) had examined some of the specimens for his thesis. In the same year Walters also published a paper on some of the Arctic collections made by Mr. S.D. MacDonald (Walters, 1953a).

In the years following 1958, valuable additions have been made to the collection by several museum staff members: Mr. S.D. MacDonald, Mr. S.W. Gorham (who became herpetological-ichthyological technician in 1964), Dr. E.L. Bousfield, Mr. F.R. Cook, and Dr. A.H. Clarke, Jr., as well as by the curator of ichthyology. Dr. Vadim D. Vladykov of the University of Ottawa has donated specimens from the Ukraine, as well as type material of the family Zoarcidae. John Scoggan of Ottawa contributed considerable Ontario material and assisted on a museum expedition to Alaska.

Many institutions have also contributed. The Arctic Unit of the Fisheries Research Board, through Mr. J.G. Hunter, has notably enhanced the museum's Arctic collection. Dr. W. Templeman of the St. John's biological station and Dr. J.L. Hart of the St. Andrews station have provided both specimens and ship space to museum personnel for collecting. Collections have also been received through Dr. P.A. Larkin from the Pacific Biological station at Nanaimo.

The following colleagues at other Canadian museums have also been generous with specimens: Mr. P. Ellickson, Dr. C.C. Lindsey, and Dr. N.J. Wilimovsky, of the Institute of Fisheries, University of British Columbia; Drs. E.J. Crossman and W.B. Scott of the Royal Ontario Museum; Mr. D. Crowdis of the Nova Scotia Museum of Science, Halifax. Staff of the Quebec fisheries department have also donated material.

Through the valuable contributions of these persons the collection has grown to 3,500 catalogued collections and 60,000 catalogued specimens including 900 species (as of the beginning of 1965). Representatives of over 210 of the 550 living families of fishes are present. A special collection of specimens, cleared and stained with alizarin or skeletonized for osteological study, includes representatives of 160 families. The collection of Canadian Arctic marine fishes is the finest in existence; the Canadian

Atlantic marine collection is one of the foremost in Canada. Representation in other regions of Canada is growing, and a representative collection of fishes of the world is being built.

LIST OF TYPE SPECIMENS

Arrangement

Below is a list of the type specimens of fishes in the National Museum of Canada. The forms are listed in phylogenetic sequence, under order and family. They are listed under the original binomen or trinomen of the type description. Following the species name is the citation of the original description, the kind of type (holotype, paratype, or syntype), the National Museum catalogue number (NMC .....), the locality, collector, collecting date, and method of capture. The citations, abbreviated in the list, are given in full under *Citations of Original Descriptions* near the end of the paper.

When type specimens were catalogued in the old Victoria Museum register, both the old and the new catalogue numbers are given.

The current name to which the types have been referred is given following each type (*Referred to*: . .) . It must be noted that several of the groups are under study and that these referrals should be regarded as provisional.

Two holotypes, reported as deposited in the collection, could not be found; these are listed at the end of the paper.

Location and Marking of Types

The type specimens are not integrated with the rest of the collection. They are placed on a separate tier of shelves near the door of the collection room. They are identified by a pink ribbon tied around the bottle, as well as by appropriate labels in the jar. A separate list of types on cards is placed at the beginning of the collection's species index. Types are also recorded in the body of this index.

LIST OF TYPE SPECIMENS IN THE NATIONAL MUSEUM OF CANADA

Order Petromyzoniformes

Petromyzonidae

Lampetra richardsoni Vladykov and Follett 1965, J. Fish. Res. Bd. Canada 22(1):143, fig. 3-9.

HOLOTYPE: NMC64-57, male, adult, Smith Creek, Cultus Lake, British Columbia, Canada, collected by G.C. Carl, 30 May 1942 (Quebec Department of Fisheries tag number 4554 red).

PARATYPES: NMC64-58, one specimen, transformed, Holmes Creek, near Duncan, Vancouver Island, British Columbia, Canada, collected by P. Parizeau, 7 May 1950 (Quebec Dept. Fish. tag number 4933 red); NMC64-59, one specimen, ammocoete, North Creek, near Alderwood, 15 miles north of Seattle, Washington, United States, collected by A.D. Welander, 16 January 1955 (Quebec Dept. Fish. tag number 3516 green).

Order Clupeiformes

SALMONIDAE

Leucichthys athabascae Harper and Nichols 1919, Bull. Am. Mus. Nat. Hist. 41:269.

HOLOTYPE: NMC58-164 (formerly Victoria Memorial Museum No. 1029), Lake Athabaska at mouth of Charlot River, northern Saskatchewan, Canada, collected by Francis Harper, Lake Athabaska Expedition, 28 June 1914. Taken from stomach of a *Salvelinus namaycush*.

REFERRED TO: *Leucichthys zenithicus* (Jordan and Evermann) by Dymond (1943); currently called *Coregonus zenithicus* (Jordan and Evermann).

Leucichthys entomophagus Harper and Nichols 1919, Bull. Am. Mus. Nat. Hist. 41:267.

HOLOTYPE: NMC58-162 (formerly Victoria Memorial Museum No. 1021), Tazin River at foot of Kolethe Rapids, Mackenzie District, Northwest Territories, Canada (about 60°38' N, 110°30' W), collected by Francis Harper, Lake Athabaska Expedition, 24 July 1914. Picked up dead with gash on caudal peduncle.

REFERRED TO: *Leucichthys zenithicus* (Jordan and Evermann) by Dymond (1943); now called *Coregonus zenithicus* (Jordan and Evermann).

Leucichthys macrognathus Harper and Nichols 1919, Bull. Am. Mus. Nat. Hist. 41:269.

HOLOTYPE: NMC58-163 (formerly Victoria Memorial Museum No. 1031), southern shore waters of Great Slave Lake, a few hundred yards offshore at Fort Resolution, Mackenzie District, Northwest Territories, Canada, collected by Francis Harper, Lake Athabaska Expedition, 26 August 1914, in a small-meshed gill net.

REFERRED TO: *Leucichthys zenithicus* (Jordan and Evermann) by Dymond (1943); currently called *Coregonus zenithicus* (Jordan and Evermann).

Osmeridae

Hypomesus transpacificus transpacificus McAllister 1963, Bull. Nat. Mus. Canada (191): 34, fig. 11 below and map.

Holotype: NMC60-499, lower San Joaquin River between Three Mile Slough and False River, California, United States, collected by United States Fish and Wildlife Service, 24 August 1949, in a surface tow.

Paratypes: NMC60-500, one specimen from same collection as holotype; NMC62-166, 32 specimens from San Joaquin River delta at Pittsburgh, Contra Costa County, California, United States, collected by California Department of Fish and Game at "New York" station 51, 26 July 1962, in trawl net (two of these sent to Dr. A.N. Svetovidov, Leningrad); NMC62-167, ten specimens, San Joaquin River at Roberts Island, San Joaquin County, California, United States, collected by California Department of Fish and Game, 9 April 1957 (one of these sent to Dr. A.N. Svetovidov, Leningrad).

Referred to: The same.

Hypomesus transpacificus nipponensis McAllister 1963, Bull. Nat. Mus. Canada (191): 36, fig. 11 above and map.

Holotype: NMC60-498-A, Lake Onuma, southern Hokkaido, Japan, collected by Dr.K. Hamanda, 19 April 1947.

Paratypes: NMC60-498, 52 specimens from same collection as holotype (one of these sent to United States National Museum; two of these sent to University of Michigan Museum of Zoology; three of these sent to Dr. A.N. Svetovidov, Leningrad; one of these sent to the Museum of Comparative Zoology, Harvard).

Referred to: The same.

Order Perciformes

Cyclopteridae

Cyclopterus lumpus hudsonius Cox 1920, Trans. Roy. Can. Inst. 12, pt. 2(28): 241, fig. 1 and 3.

Holotype: NMC58-26 (formerly Victoria Memorial Museum No. 58), Fort Churchill, Hudson Bay (now Churchill, Manitoba), collected by Dr. Robert Bell of the Geological Survey of Canada, at the beginning of September, 1885.

Referred to: Subspecies not recognized by Lindberg and Legeza (1955).

Lycodes lavalaei Vladykov and Tremblay 1936, Fauna et Flora Laurentianae, Stat. Biol. St. Laurent, U. Laval (1): 31, pl. IV, fig. 9; pl. V, fig. 10 and 11a.

PARATYPES: NMC60-157, one specimen from St. Lawrence River estuary between 4 miles northwest to 4 miles west of Trois Pistoles, Quebec, Canada, collected by Station Biologique du St. Laurent, trawl no. 150, station 121 to 120, 1 August 1935; NMC60-158, one specimen from Newfoundland, Canada, collected by Dr. H. Thompson.

REFERRED TO: Regarded as a close relative of *Lycodes raridens* Taranetz and Andriashev by Andriashev (1954).

Lycodes reticulatus laurentianus Vladykov and Tremblay 1936, Fauna et Flora Laurentianae, Stat. Biol. St. Laurent, U. Laval (1): 34, pl. V, fig. 11b, pl. VI, fig. 12.

PARATYPE: NMC60-159, one specimen from St. Lawrence River estuary between Trois Pistoles and Tadoussac, Quebec, Canada, collected by Station Biologique du St. Laurent, trawl no. 169, station 113 to 118, 22 August 1935.

REFERRED TO: Status of this subspecies is not clear according to Andriashev (1954) and Backus (1957).

Lycodes turneri atlanticus Vladykov and Tremblay 1936, Fauna et Flora Laurentianae, Stat. Biol. St. Laurent, U. Laval (1): 38, pl. VII, fig. 14, 15, 16.

PARATYPE: NMC60-160, one specimen from Strait of Belle Isle at Bonne Esperance, Quebec, Canada, collected by the "Prince" at station 450, 13 September 1923, in a shrimp trawl.

REFERRED TO: *Lycodes polaris* (Sabine) by Andriashev (1954); the species group name *atlanticus* is preoccupied by *Lycodes atlanticus* Jensen, 1901.

Lycodes vachonii Vladykov and Tremblay 1936, Fauna et Flora Laurentianae, Stat. Biol. St. Laurent, U. Laval (1): 23, pl. 1, fig. 3 and 4; pl. II, fig. 5.

PARATYPES: NMC60-156, one specimen from St. Lawrence River estuary between 7 miles southeast to 11 miles south of Les Escoumains, Quebec, Canada, collected by Station Biologique du St. Laurent, trawl no. 59, station 130 to 123, 21 August 1933; NMC60-163, one specimen from St. Lawrence River estuary between 23 miles west to 11 miles southwest of Pointe au Père, Quebec, collected by Station Biologique du St. Laurent, trawl no. 172, station 149 to 143, 23 August 1935.

REFERRED TO: *Lycodes esmarki* Collett or possibly a distinct subspecies by Andriashev (1954).

Lycodes vahlii maculatus Vladykov and Tremblay 1936, Fauna et Flora Laurentianae, Stat. Biol. St. Laurent, U. Laval (1): 27, pl. III, fig. 7 and 8.

PARATYPES: NMC60-161, one specimen from St. Lawrence River estuary between 4 miles northwest to 4 miles west of Trois Pistoles, Quebec, Canada, collected by Station Biologique du St. Laurent, trawl no. 3, station 121 to 120, 7 July 1932; NMC60-162, 23 specimens from middle of St. Lawrence River estuary between Bic and Les Escoumains, collected by Station Biologique du St. Laurent, trawl no. 173, station 144 to 145, 23 August 1935 (one of the 23 sent to Royal Ontario Museum, one other sent to the Institute of Fisheries, University of British Columbia).

REFERRED TO: *Lycodes vahli gracilis* Sars by Andriashev (1954) or closely related to it.

Order Gasterosteiformes

GASTEROSTEIDAE

Gasterosteus pungitius brachypoda Bean 1879, Bull. U.S. Nat. Mus. (15): 129.

SYNTYPE: NMC58-13 (formerly United States National Museum No. 21773, then Victoria Memorial Museum No. 154), one specimen from pond on Oosoadlin Mountain, Cumberland Gulf, Baffin Island, Northwest Territories, Canada, collected by Ludwig Kumlien on the Howgate Polar Expedition of 1877-78, in July 1878.

REFERRED TO: *Pungitius pungitius* or *P.p. pungitius* (Linnaeus) (Linnaeus) by current authors; subspecies not recognized.

LIST OF SPECIMENS DEPOSITED IN, BUT NOT FOUND AT, THE NATIONAL MUSEUM OF CANADA

Opsopoeodus borealis Harper and Nichols 1919, Bull. Am. Mus. Nat. Hist. 41:266.

HOLOTYPE: Victoria Memorial Museum No. 1048, Lake Athabaska, Fort Chipewyan, Alberta, Canada, collected by Francis Harper, 15 June 1914, in a hand-net. The specimen could not be found at the author's arrival at the Museum in 1958.

REFERRED TO: *Notropis hudsonius selene* (Jordan) by Kendall (1924), which is currently named *Notropis hudsonius hudsonius* (Clinton).

Coregonus preblei Harper and Nichols 1919, Bull. Am. Mus. Nat. Hist. 41:266, pl. XV, fig. 2.

HOLOTYPE: Victoria Memorial Museum No. 1038, Tazin River, about one mile above its confluence with the Taltson River, Mackenzie District, Canada, collected by Francis Harper, 28 July 1914, picked up dead in river. Dr. J.R. Dymond (1943) reported that he was unable to locate this

specimen in the National Museum of Canada. Nor could it be found in the museum at the author's arrival in 1958.

REFERRED TO: *Prosopium cylindraceum* by Dymond (1943), for which a subspecies is currently recognized by some authors, *P. c. quadrilaterale* (Richardson).

SUMMARY

A list of the type specimens in the National Museum of Canada with a short history of the fish collection of that institution is given. The collection has grown to about 60,000 catalogued specimens since a catalogue was begun in 1914. The following types are lodged in the collection: Petromyzonidae: *Lampetra richardsoni* Vladykov and Follet (holotype +paratypes); Salmonidae: *Leucichthys athabascae* Harper and Nichols (holotype; *Leucichthys entomophagus* Harper and Nichols (holotype); *Leucichthys macrognathus* Harper and Nichols (holotype); Osmeridae: *Hypomesus transpacificus transpacificus* McAllister (holotype +paratypes); *Hypomesus transpacificus nipponensis* McAllister (holotype + paratypes); Cyclopteridae: *Cyclopterus lumpus hudsonius* Cox (holotype); Zoarcidae: *Lycodes lavalaei* Vladykov and Tremblay (paratypes); *Lycodes reticulatus laurentianus* Vladykov and Tremblay (paratype); *Lycodes turneri atlanticus* Vladykov and Tremblay (paratype); *Lycodes vachonii* Vladykov and Tremblay (paratypes); *Lycodes vahlii maculatus* Vladykov and Tremblay (paratypes); Gasterosteidae: *Gasterosteus pungitius brachypoda* Bean (syntype). Two types reported deposited in the National Museum of Canada could not be found: *Opsopoeodus borealis* Harper and Nichols (holotype) and *Coregonus preblei* Harper and Nichols (holotype).

CITATIONS OF ORIGINAL DESCRIPTIONS

The papers in which are found the original descriptions of the type specimens are cited below in full with the date of publication.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

Further Notes on Alberta Leeches (Hirudinea)

J. E. Moore

Department of the Secretary of State

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1966

NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

Further Notes on Alberta Leeches (Hirudinea)

J.E. Moore

In 1962 the writer carried out a preliminary study of the leeches of Alberta and subsequently presented (Moore, 1964) a considerable body of data relating to the distribution, reproduction, food habits, and other features of this group. The additional information acquired during the summers of 1963 and 1964 forms the subject of the present paper. The source of the material reported here includes specimens collected by the author, by students, and by other individuals in various parts of Alberta. Some special detailed studies which I carried out at the same time are also included.

As a result of the 1962 studies, a total of 16 species were recorded for the Province of Alberta. The more recent investigations have revealed the presence of three additional species, *Glossiphonia heteroclita* (Linnaeus), 1758; *Helobdella fusca* (Castle), 1900; and *Dina dubia* Moore and Meyer, 1951. The first two forms are members of the family Glossiphoniidae; the last is a representative of the family Erpobdellidae. Data for these and some other Alberta leeches are given in the following notes.

Glossiphonia complanata has been recorded from twenty-four localities to which may be added the following: Ball L., Big Island L., Boag L., Cooking L., Half Moon L., Lost L., Skeleton L., Sturgeon River, a pond near Duffield, and an unnamed lake near Edmonton. There is no doubt that G. *complanata* is widely distributed throughout the area and that this species has been found whenever detailed studies of lakes or permanent ponds were made.

On May 25, 1964, I found a single specimen which was covering 121 eggs (apparently in four capsules) attached to a piece of board. The capsules were cemented to the board, and the parent's body was simply covering them. This procedure is apparently typical of G. *complanata* in England, as reported by Mann (1962). Once the eggs have hatched they become attached to the ventral surface of the body by their embryonic attachment organs and subsequently are carried around by the parent. According to Mann (1962), the average number of young produced by this species in England is 26. This is in marked contrast to the large number of eggs herewith recorded for the Canadian species. Moore (1912) also makes mention of the large number of eggs produced by G. *complanata* in Minnesota. Furthermore, Mann states that in England this species breeds from March to May and produces two broods. As far as I am aware there are no data for this species to indicate the production of two broods of young in a season in North America.

Glossiphonia heteroclita was found in only one locality – a permanent pond near Edmonton on August 10, 1963. This constitutes the first record for Alberta, the single specimen obtained being identified by Dr. M.C. Meyer of the University of Maine. This is a very small species which might be overlooked quite easily during any general collecting activities. It is apparently widely distributed across Canada and is known from Manitoba, Ontario, and Quebec (Moore and Meyer, 1954). In addition, the writer has one specimen collected from a pothole near Melfort, Saskatchewan, by Mr. D.R. Foskett on May 4, 1963.

Helobdella fusca was found for the first time in Alberta during the summer of 1963. I collected four adult specimens in a permanent pond near Edmonton on August 10. The specific determination was made by Dr. M.C. Meyer. That all four individuals bore egg capsules indicates this is a rather late breeding species of glossiphoniid. Two very small specimens, presumably recently released, were taken in Cottage Lake on August 4, 1963. *H. fusca* has been recorded from Manitoba, Ontario, Quebec, and the Northwest Territories (Meyer and Moore, 1954) and hence is quite widely distributed across Canada.

Helobdella stagnalis has been recorded from sixteen bodies of water in Alberta and is known to occur also in the following: Boag L., Cooking L., Half Moon L., Joseph L., Lost L., Ministik L., Skeleton L., Twin Island L., and in a pond near Hinton, Alberta. I suspect that it has a very wide distribution in Alberta, but because of its small size it has not been taken during random collecting in this Province.

On the basis of a special study of specimens from a permanent pond near Edmonton, it appears that the number of young produced is rather small. Using data for six individuals I found that the number of young ranged from 17 to 23 with an average of 20. Further studies revealed that 25 parents died after producing young in the spring and summer of 1964. Thus it would appear that, as in the case of *H. stagnalis* in England (Mann, 1962), those individuals which survive the winter breed and then die. Though a second reproductive cycle occurred in 1962, this did not prove to be the case in the permanent pond in 1964, probably because of the much cooler water temperatures than usual for the late summer. In larger bodies of water, conditions may have been different, e.g., of the 100 specimens taken in Cooking Lake on October 16 and 30, 1964, 56 showed no signs of gonadal development, and the rest had well-developed gonads.

Data for two additional specimens from the permanent pond revealed that in *H. stagnalis* the eggs hatch in about 5 days, the embryo stage lasts 3 days, and the young may be carried by the parent for 15 to 30 days.

As a result of aquarium feeding experiments it has been learned that *H. stagnalis* feeds on such invertebrates as chironomid larvae, oligochaetes, and small snails.

Oculobdella lucida was reported previously from six Alberta localities and is now known to occur in eight additional ponds. Six of these are temporary ponds located within a one-mile radius of the temporary pond in which the species was found in 1962. The other two records are a pond near Beaverlodge, Alberta, and a pond five miles south of Namao. This species appears to be a common inhabitant of temporary and permanent ponds and also of shallow, weedy lakes.

Earlier studies (Moore, 1964) raised some questions regarding the reproduction of *O. lucida* in temporary ponds. Some of these were answered by extensive observations of breeding activities of specimens from a temporary pond near Edmonton, Alberta. Transfer of spermatophores (of the *Placobdella parasitica* type – see Mann, 1942, p. 105) was observed in several instances, and it was noted that following an exchange of spermatophores these structures disappeared in two hours or less. Observations made on five pairs of *O. lucida* from the time of mating until the release of young revealed the following information: *C. lucida* deposits eggs 3–6 days after mating, holds the eggs in capsules for a further 3–6 days, holds them by the embryonic attachment organ for 3–4 days, and then shelters the young leeches for at least 9–14 days and often longer. The whole process thus occupies three to four weeks or perhaps longer.

A number of adults from the same temporary pond were retained in aquaria in order to see if breeding might occur more than once during a season. It was observed that a total of 11 individuals produced two broods of young during the spring and early summer. The first brood appeared in early May and the second about one month later. In some instances it was noted that a second group of capsules appeared while the parent still sheltered a few young belonging to the first brood. These data indicate that *O. lucida* which survives the winter in a temporary pond will be able in some cases to produce two broods of young during the season. Although the species possesses this potential, breeding is dependent upon the pond not drying up before it breeds a second time.

It was found that young which were produced in the spring can mature and reproduce later that same year. Actually under laboratory conditions breeding of young took place about two months after they were released from the parent. Because of the time interval involved, it seems unlikely that such a situation would occur very often in nature, but it is a possibility during wet years .

It has already been pointed out (Moore, 1964) that *O. lucida* in a temporary pond bore an average of 156 young. Egg counts for five medium

and large-sized *O. lucida* from a permanent pond revealed the presence of from 77 to 128 eggs with the average being 98. On the basis of these data, it would appear that the reproductive potential of this species in a temporary pond is considerably higher than in a permanent pond.

Placobdella ornata was recorded previously from thirteen Alberta localities and may now be reported also from the following: Boag L., Half Moon L., Hastings L., Hermit L., Lost L., Ministik L., a pond near Duffield, Alta., and in a beaver pond near the Alberta Biological Station at Gorge Creek. The specimen from the last-mentioned body of water was collected on July 6, 1963, and found to be bearing young.

In an attempt to learn something of the feeding habits of this species, specimens with empty digestive tracts were left for one-month intervals with the following amphibians – a salamander *(Ambystoma tigrinum melanostictum)*, a toad (*Bufo woodhousei hemiophrys*), and a frog (*Rana sylvatica cantabrigensis*). In no instance did the leeches attach themselves to these amphibians. As mentioned earlier (Moore, 1964), a partly distended specimen of *P. ornata* was found among the feathers of a Horned Grebe. Our only additional information arises from the presence of this leech in the nasal cavity of a Baldpate (*Marcea americana*) taken at Cooking Lake on August 17, 1964, and also in the nasal cavity of a Coot *(Fulica americana)* collected at Big Island Lake on June 17, 1963, by Mr. M. Colbo. From these rather sparse data it would appear that *P. ornata* subsists on blood extracted from various kinds of aquatic birds. The only other information on feeding habits appears to be a reference by Moore (1912) to the fact that in Minnesota *P. ornata* feeds, in part, on the blood of turtles.

It may be mentioned that this species can exist for long periods of time when the digestive tract is full of blood. Some of my specimens collected in June with a well-filled digestive tract still showed the presence of a considerable quantity of blood after six months had elapsed.

An interesting feature of *P. ornata* is the ability of small and medium-sized individuals to swim like an erpobdellid. They are not strong swimmers, however, and appear to be able to keep up this activity for a short distance only. As far as I am aware, they are the sole members of the family Glossiphoniidae which are able to swim.

Our previous report refers to the existence of the breeding season for *P. ornata* during the summer months. In a permanent pond near Edmonton this was confirmed by the collection of members of this species, bearing young, on July 30, August 18, and September 1, 1964.

Theromyzon rude

The following ten localities represent records of this species which are in addition to those previously mentioned: Astotin L., Ball L., Boag L.,

Bow River, Ministik L., Twin Island L., Wolfe L., a pond near Hinton, Alta., a pond at Mile 95 on the Mackenzie Highway, and a pond 5 mi. south of Namao, Alta.

As indicated in the 1964 paper, this species is an inhabitant of the nasal cavities of grebes in Alberta. It is now possible to extend the list to include a number of kinds of aquatic birds not mentioned before. *T. rude* has been found in the nasal cavities of young specimens of Gadwall (*Anas strepera*), Pintail (*Anas acuta*), and Shoveler (*Spatula clypeata*), an adult Baldpate (*Marcea americana*), and young and adult Coots (*Fulica americana*). Mr. R.H. Mackay of the Canadian Wildlife Service collected a distended *T. rude* from the trachea of a dead Trumpeter Swan (*Olor buccinator*) cygnet at Wolfe Lake – it is thought that the presence of the leech probably resulted in the suffocation of the cygnet. Specimens of *Theromyzon* sp. were taken from the nasal cavities of young Blue-winged Teal (*Anas discors*), Gadwall, Lesser Scaup (*Aythya affinis*), Mallard (*Anas platyrhynchos*), and Shoveler, as well as from a Whistling Swan (*Olor columbianus*) cygnet collected near Calgary, and from a Western Grebe (*Aechmophorus occidentalis*). Although most of these birds harboured only from one to three or four leeches, there was one young Shoveler which had a total of eighty-eight very small *T.* sp. in its nasal cavities. It is evident then that *Theromyzon* infests young and adult water birds of several types including Coots, Grebes, Ducks, and Swans in Alberta. More extensive observations would probably result in the detection of this leech in many species which are not indicated here. Although *T. rude* is suspected of being the cause of death in only one instance, it may be that this leech is responsible for a considerable degree of mortality in young water birds of this area.

Some information on reproduction in this species was provided by two individuals collected from a permanent pond near Edmonton on July 1. One of these produced four capsules on July 7. The capsules, which were covered closely by the parent's body, were attached to the glass of the aquarium. The parent remained stationary until July 13 when the eggs hatched into embryos which became attached to the ventral surface of the adult's body. Thereafter the parent leech began to crawl around in the aquarium. Four days later the embryos had developed into young which began to leave the parent on August 19 and continued to leave until August 27, at which time the parent died. The other adult produced four capsules on July 10, had embryos on July 16 and young on July 20. The number of young in this instance was 191.

Thus it is evident that *T. rude* breeds in Alberta during the summer months, and that in the two examples referred to above the capsule stage lasted six days and the embryo stage four days. The young, which were present ten days after capsule deposition, remained with the parent for one month or longer.

Haemopis marmorata was found in the following lakes in addition to the fifteen from which it had been reported previously: Astotin L., Big Island L., Boag L., Cooking L., Half Moon L., Hastings L., Lost L., Ministik L., Skeleton L., and Surprise L., near Edson, Alta. This species seems to be characteristic of the larger bodies of water known as lakes and to be absent from those waters which are known locally as 'sloughs.' It was the only Alberta leech to be found out of the water—frequently it occurred beneath logs or rocks situated on shore well beyond the water's edge.

Moore (1912) reports that this species takes a wide range of food material; this is borne out by the study of stomach contents which showed the presence of oligochaetes, insect larvae, small pelecypods, and other leeches such as *Helobdella stagnalis*, *Erpobdella punctata*, and *Dina dubia*.

A large specimen of *H. marmorata* collected in Half Moon Lake on July 31, 1964, showed the presence of a well-developed clitellum. Juvenile individuals were quite common in Cooking Lake on October 16, 1964. These two sets of records constitute our only information concerning the breeding habits of *H. marmorata* in Alberta.

Erpobdella punctata is a widely distributed species previously reported from twenty-three Alberta localities. It may now be recorded also for the following fifteen additional bodies of water: Astotin L., Ball L., Boag L., Cooking L., Half Moon L., Hastings L., Lost L., North Saskatchewan River, Peach L., Skeleton L., an unnamed lake near Edmonton, a pond near Duffield, a pond at Mile 95 on the Mackenzie Highway, two beaver ponds near the Alberta Biological Station at Gorge Creek, Alta.

A study of stomach contents of this leech revealed that it feeds on a variety of aquatic insect larvae, e.g., beetle and chironomid larvae, and it has been observed to feed actively on oligochaetes. It is preyed upon by other leeches such as *H. marmorata*, as mentioned above, and also by ducks. Our evidence for the latter consists of a single specimen of *E. punctata* taken from the oesophagus of a Lesser Scaup (*Aythya affinis*) collected at Hastings Lake.

Breeding activities commence in May, and the occurrence of juvenile individuals in the various lakes and ponds is proof that they continue through much of the summer.

Dina dubia was collected for the first time in Alberta during the spring and summer of 1964. Until now this species has been taken from four localities, i.e., Bow River near Calgary, Alta., Astotin L., Big Island L., and Skeleton L. near Boyle, Alta. Specimens from the Bow River and from Astotin and Skeleton lakes were identified by Dr. M.C. Meyer. This species was described by Moore and Meyer (1951) on the basis of material from Great Slave Lake, N.W.T. Since then it has been reported only from Saskatchewan where it occurred in two localities (Oliver, 1958).

We have no information on the feeding habits of this species but do know that it serves as prey for other leeches such as *H. marmorata*. Two specimens of the latter from Skeleton Lake each contained a single *D. dubia* in its stomach. Our only data on breeding are provided by seven individuals from Skeleton Lake taken on May 31, 1964, all of which possessed well-developed clitellar regions.

Nephelopsis obscura was reported previously from more bodies of water than any other Alberta leech and is known to occur also in the following: Ball L., Boag L., Bow River, Cooking L., Half Moon L., Joseph L., Lost L., Ministik L., Skeleton L., Sturgeon R., two ponds near Duffield and one near Hinton, Alta., and an unnamed lake near Edmonton.

Insect larvae are the only food items I have found in the stomachs of representatives of this species, but it is reported by Moore (1912) to feed also on oligochaetes, aquatic snails, and so on. Like *E. punctata* it serves as food material for at least one kind of duck (three specimens were found in the oesophagus of a Lesser Scaup collected at Hastings Lake).

Such evidence as we possess indicates that the breeding habits of *N. obscura* are similar to those of *E. punctata*.

DISCUSSION

Nineteen species of leeches have now been reported from Alberta, seven of which (*Glossiphonia complanata, Helobdella stagnalis, Placobdella ornata, Theromyzon rude, Haemopis marmorata, Erpobdella punctata,* and *Nephelopsis obscura)* may be considered as widely distributed in the central and southern parts of the Province. Indeed it would appear that intensive collecting at any of our Alberta lakes would reveal the presence of most, if not all, of these species. Table 1 shows the occurrence of leeches in eight lakes, which were subjected to detailed studies.

All 19 species of Alberta leeches have been reported from other parts of Canada, and the ranges of some of them, such as *G. complanata, H. stagnalis, H. marmorata, E. punctata,* and *N. obscura,* include practically all the major areas in Canada (Meyer and Moore, 1954).

All the Alberta species except *O. lucida* and *D. dubia* are found in the United States, and three of them (*Glossiphonia complanata, G. heteroclita,* and *Helobdella stagnalis)* also occur in Europe (Mann, 1962). *O. lucida* has been taken only in the three Prairie Provinces of western Canada, and *D. dubia* has been reported previously only from Great Slave Lake in the Northwest Territories and from two localities in Saskatchewan. At present it would appear that these last two species are confined to the region of central Canada.

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TABLE 1

Leech fauna of eight Alberta Lakes

	Glossiphonia complanata	*Helobdella stagnalis*	*Placobdella ornata*	*Theromyzon rude*	*Haemopis marmorata*	*Erpobdella punctata*	*Nephelopsis obscura*
Astotin Lake	X	X		X	X	X	X
Big Island Lake	X		X		X	X	X
Boag Lake	X	X	X	X	X	X	X
Cooking Lake	X	X	X	X	X	X	X
Half Moon Lake	X	X	X		X	X	X
Kehiwin Lake	X	X	X		X	X	X
Lost Lake	X	X	X		X	X	X
Skeleton Lake	X	X			X	X	X

+ The

Complete list of leeches reported from Alberta localities:

Order **RHYNCHOBDELLIDA**

Family **Glossiphoniidae**

Glossiphonia complanata (Linnaeus), 1758
G. heteroclita (Linnaeus), 1758
Helobdella fusca (Castle), 1900
H. stagnalis (Linnaeus), 1758
Oculobdella lucida Meyer and Moore, 1954
Placobdella ornata (Verrill), 1872
P. papillifera (Verrill), 1872
P. parasitica (Say), 1824
Theromyzon meyeri (Livahow), 1902
T. rude (Baird), 1863

Family **Piscicolidae**

Illinobdella moorei Meyer, 1940
Piscicola milneri (Verrill), 1871

Order **GNATHOBDELLIDA**

Family **Hirudidae**

Haemopis grandis (Verrill), 1874
H. marmorata (Say), 1824

Order **PHARYNGOBDELLIDA**

Family **Erpobdellidae**

Dina dubia Moore and Meyer, 1951
D. parva Moore, 1912
Erpobdella punctata (Leidy), 1870
Mooreobdella fervida (Verrill), 1874
Nephelopsis obscura Verrill, 1872

Revised Key to the Species

1 Mouth a small pore in the oral sucker through which a muscular proboscis may be protruded; jaws absent..... .....Order RHYNCHOBDELLIDA 3

— Mouth large occupying entire cavity of oral sucker; no proboscis 2

2 Eyes 5 pairs forming lateral arches on II to VI; jaws present or absent .... Order GNATHOBDELLIDA
Family Hirudidae 13

— Eyes 3 or 4 pairs in separate labial and buccal groups; jaws absent..... .....Order PHARYNGOBDELLIDA
Family Erpobdellidae 14

3 Body at rest usually flattened and not divided into distinct anterior and posterior regions; head sucker not distinctly marked off from body; 3 annuli per segment in the mid-body region .....Family Glossiphoniidae 4

— Body at rest cylindrical and usually divided into distinct anterior and posterior regions; 14 annuli per segment in the mid-body region. Family Piscicolidae 12

4 Eyes 1 or more pairs well separated 5

— Eyes 1 pair close together or apparently united..... 11

5 Eyes 1 pair..... 6

— Eyes 3 or 4 pairs..... 8

6 Gonopores separated by 1 annulus, last crop caeca strongly reflexed 7

— Gonopores united; last crop caeca slightly or not at all reflexed .... *Oculobdella lucida*

7 Horny scute on dorsum of annulus 12.....*Helobdella stagnalis*

— No horny scute; dorsum with a pattern of brown longitudinal stripes . .*H. fusca*

8 Eyes 3 pairs..... 9

— Eyes 4 pairs..... 10

9 Eyes in 2 paramedian rows; a pair of dark stripes in dorsum and venter; gonopores separated by 2 annuli..... ..... *Glossiphonia complanata*

— Eyes in a roughly triangular pattern of 3 groups of 2 each; first pair of eyes closer together than other pairs; no paired stripes; gonopores united ....*G. heteroclita*

10 Gonopores separated by 2 annuli ..... *Theromyzon meyeri*

— Gonopores separated by 3 annuli .....*T. rude*

11 With large rough dorsal tubercles and numerous smaller ones; colour pattern a fine mixture with a median dorsal light stripe interrupted by short brown longitudinal lines; venter unstriped ..... *Placobdella ornata*

— With small but numerous dorsal tubercles; dorsum with longitudinal brown stripes; venter unstriped ..... *P. papillifera*

— With dorsal tubercles inconspicuous or absent; bold pattern of brown, green, and yellow on dorsum; venter with bluish stripes ..... *P. parasitica*

12 Pulsatile vesicles on sides of body; suckers distinctly marked off from body ..... *Piscicola milneri*

– No pulsatile vesicles; suckers not distinctly marked off from body .... *Illinobdella moorei*

13 3rd annulus of VII and 1st of VIII enlarged but only faintly or not at all divided; jaws and teeth present, teeth 12-16 pairs ..... *Haemopis marmorata*

– 3rd annulus of VII and 1st of VIII enlarged and subdivided; jaws and teeth absent ..... *H. grandis*

14 Annulus b6 not obviously enlarged or subdivided; eyes 3 pairs; 2 or 4 longitudinal rows of black spots on dorsum ..... *Erpobdella punctata*

– Annulus b6 obviously enlarged; eyes 4 pairs (except in some *M. fervida* which have 3 pairs); no longitudinal rows of spots on dorsum 15

15 Gonopores separated by 3-3½ annuli 16

– Gonopores separated by 2 annuli 17

16 Length about 1 inch; a few dark spots or no pigment .... *Dina parva*

– Length 2 inches or less; median dorsal dark stripe..... ..... *D. dubia*

17 Vas deferens with a long preatrial loop; usually with irregular blotches on dorsum ..... *Nephelopsis obscura*

– Vas deferens without preatrial loop; colour in life pale red .... *Mooreobdella fervida*

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NATIONAL MUSEUM OF CANADA **NATURAL HISTORY PAPERS**

STUDIES OF THE BYRON BOG IN SOUTHWESTERN ONTARIO XXIV. DISTRIBUTION OF FINGERNAIL AND PILL CLAMS (PELECYPODA: SPHAERIIDAE)

W. W. Judd

Department of the Secretary of State

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QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

Studies of the Byron Bog in Southwestern Ontario XXIV. Distribution of Fingernail and Pill Clams (Pelecypoda: Sphaeriidae)

W. W. JUDD*

During 1961, studies were undertaken on the non-insect invertebrates of the Byron Bog at London, Ontario, as part of a programme of studies sponsored by the National Museum of Canada. The Byron Bog and its vegetation zones have been described by Judd (1957).

In 1961 regular daily collections of invertebrates were made from May 8 to September 29 in the four different regions of the bog (Judd, 1957). These four regions are dry, wooded slopes (c); lower, damp region (b); open floating bog (a); and the open pond, Redmond's Pond (d). In regions (a), (b), and (c), plots were marked out with stakes, each plot 250 feet by 50 feet in size (see Fig. 1, Judd, 1963). Each plot, in turn, was divided into five smaller sub-plots of dimensions 50 feet by 50 feet, numbered from 1 to 5. Starting on May 8, collections were made in sub-plots numbered '1' in regions (a), (b), and (c). The next day collections were made in sub-plots numbered '2.' This procedure was followed, in sequence, on successive days in plots numbered '3,' '4,' and '5.' This procedure, which was repeated throughout the summer, prevented daily disturbance of the population of animals in any one sub-plot. Invertebrates were searched for in soil and moss and under objects on the ground. Collections in region (d), Redmond's Pond, were made daily by making three sweeps about three yards long through the water with a dip-net having a mouth 10 inches in diameter. Aquatic animals were collected with the dip-net in pools that were present in spring in regions (a), (b), and (c).

Among the invertebrates collected were clams of the family Sphaeriidae. During the summer of 1961 Mr. M.S. Beverley aided in collecting and sorting specimens. The clams were identified by Rev. H.B. Herrington, Westbrook, Ontario. Most of the specimens are deposited in the Natural History Branch, National Museum of Canada; a few, representing the various species collected, are deposited in the collection of the Department

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of Zoology, University of Western Ontario. The distribution of the various species among the regions of the bog is shown in Table 1.

TABLE 1

Numbers of clams from regions of the bog

Species	Region (a) Open floating bog	Region (b) Pools in damp, low area	Region (c) Temporary pools on wooded slopes	Region (d) Open pond
Sphaerium securis	0	5	2	807
Sphaerium occidentale.....	0	14	205	0
Pisidium casertanum.....	0	116	3	1
Pisidium casertanum forma *roperi*.....	0	12	0	0
Pisidium ventricosum forma *rotundatum*	0	5	1	0

The four species collected were *Sphaerium securis* Prime, *Sphaerium occidentale* Prime, *Pisidium casertanum* (Poli) including forma *roperi* Sterki, and *Pisidium ventricosum* forma *rotundatum*. These have all previously been recorded from Ontario (Heard, 1962*a*, 1962*b*, 1963; Herrington, 1962). Heard (1962*a*) shows that they are present in the three Great Lakes – Huron, Erie, and Ontario – which surround the peninsula of southwestern Ontario in which the Byron Bog is situated. Heard (1962*b*) shows that all four species occur in both the Mississippi and Great Lakes drainages, and points out that the northward migration route of such clams after the Pleistocene glaciation was through glacial Lake Maumee. This lake penetrated northward in southwestern Ontario as far as the present city of London which includes the Byron Bog (Chapman and Putnam, 1950). Heard (1962*b*) discounts dispersal of sphaeriid clams by aquatic animals and overland carriage as major means of dispersal and concludes that the distribution of sphaeriids was originally accomplished by active migration through drainage patterns. Thus it may be possible that clams entered the Byron Bog from the south by Lake Maumee, an interpretation in keeping with the status of this bog as a relict of the retreat of the glaciers.

ACCOUNT OF SPECIES COLLECTED

Table 1 shows that sphaeriids were collected in regions (b), (c), and (d) of the bog but not in (a). As will be noted in the following account, the various species collected are characteristic of either permanent ponds and lakes or of areas which dry up in summer. Region (a) remains in a permanently soggy state through the year but has no large areas of open water in it and thus does not afford a suitable habitat for those species collected.

Sphaerium securis Prime – May 9 to September 22, with collections on most intervening dates. Juveniles were collected on May 9, 11, August 28, and September 22. The great majority were from region (d), Redmond's

Pond, and only a few were from (b) and (c). This distribution is in accord with the report of Herrington (1962) that this species is found in ponds, lakes, and rivers.

Sphaerium occidentale Prime – May 9 to August 30, with collections on most intervening dates. Juveniles were collected on June 8 and 10. The great majority were from region (c) with only a few from (b) and none from (d). This distribution is in accord with the reports of Herrington (1962) and Thomas (1963) that this species occurs in still waters of swamps, ditches, and ponds, among grass and leaves, and has a preference for, or requires, a habitat that dries up for part of the year. Region (c) comprised dry, wooded slopes. The clams were collected in hollows and at the base of the slopes where temporary pools formed in spring and dried up after the middle of June.

Pisidium casertanum (Poli) – May 10 to August 24, with collections on most intervening dates. Juveniles were collected on May 10, 17, 23, and June 8. Most of these clams were from region (b) with only a few from (c) and (d); all specimens of forma *roperi* Sterki were from region (b). The concentration of this species in region (b) is in accord with the report of Herrington (1962) that it has succeeded in adapting to wide variations of habitat and is found in bog ponds, ponds, swamps that dry up for several months of the year, swamp-creeks, creeks, rivers, and lakes. Region (b) is an area of damp ground beneath larch, spruce, and shrubs with shallow standing water till mid-June and damp mud and moss hummocks thereafter.

Pisidium ventricosum forma *rotundatum* – Region (b): May 12, 15, August 13, 14; Region (c): July 24. This was the least common species collected. Herrington (1962) records that forma *rotundatum* is found in sheltered spots in lakes, creeks, and rivers, but is not commonly found in ponds and lagoons. Its occurrence in region (b) and (c) is in accord with his report that it usually takes shelter among dead leaves of trees.

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Number 34 January 30, 1967

NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

H REMAINS FROM A 700-YEAR-OLD SOUTHERN ONTARIO ARCHAEOLOGICAL SITE

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and
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Department of the Secretary of State

ROGER DUHAMEL, F.R.S.C.
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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

Fish Remains from a 700-Year-Old Southern Ontario Archaeological Site

S.U. QADRI* and D.E. MCALLISTER

RÉSUMÉ

Dans un emplacement archéologique de la période primitive des Iroquois de l'Ontario, vieux de 700 ans et situé près de Carlisle, dans le comté d'Halton (Ontario), on a trouvé des vestiges des espèces suivantes: *Acipenser fulvescens, Amia calva, Cristivomer namaycush, Esox lucius, Catostomus* sp., *Semotilus atromaculatus, Ictalurus nebulosus, Roccus chrysops, Micropterus dolomieui, Stizostedion vitreum,* and *Aplodinotus grunniens.*

SUMMARY

Remains of the following species were found in a 700-year-old early Ontario Iroquois stage archaeological site near Carlisle, Halton Co., Ontario: *Acipenser fulvescens, Amia calva, Cristivomer namaycush, Esox lucius, Catostomus* sp., *Semotilus atromaculatus, Ictalurus nebulosus, Roccus chrysops, Micropterus dolomieui, Stizostedion vitreum,* and *Aplodinotus grunniens.*

INTRODUCTION

Remains from archaeological sites opportunely provide samples for a period usually unrepresented by fossils. An archaeological investigation in 1962 of the Bennett site, a late Pickering branch component of the Early Ontario stage, has uncovered fish remains. These are analysed here because of their historical interest to ichthyologists.

The site (AiGx-1) is located near Carlisle, in lot 14, concession 1, Nelson township, Halton County, northwest of the western end of Lake Ontario. A seriational estimate of the site's date places it at about A.D. 1250, and two carbon 14 samples gave readings of A.D. 1260 ± 130 (GSC-143) and A.D. 1280 ± 100 (M-1527). An archaeological paper on the site will be published as a bulletin of the National Museum of Canada.

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The fish remains were recovered from pits at the site. They are stained a light brown and are eroded little. The species represented are ones that occur in the warmer boreal waters, except for the lake charr, which ranges north into the Arctic. These species are all known to occur in this general area today. The present site contains eleven species, more than any previous individual site (McAllister, 1961, 1962; McAllister and Qadri, 1965). The creek chub and the bowfin, absent in other studies, are reported for the first time from an Ontario archaeological site. These two species bring the total number of fish species known from Ontario archaeological sites to eighteen. The species found in the present site are listed below in phylogenetic order under the appropriate family.

SPECIES REPRESENTED

ACIPENSERIDAE

Acipenser fulvescens Rafinesque – lake sturgeon

This species is recognizable from a portion of a scute and a fulcra (Plate I, fig. 1a and b). For its distribution consult Hubbs and Lagler (1958), McAllister (1962), and McAllister and Qadri (1965).

AMIIDAE

Amia calva Linnaeus – bowfin

The species identification is based on the 2nd postorbital bone (Plate I, fig. 2). For its present distribution see Hubbs and Lagler (1958) and Smith (1962).

SALMONIDAE

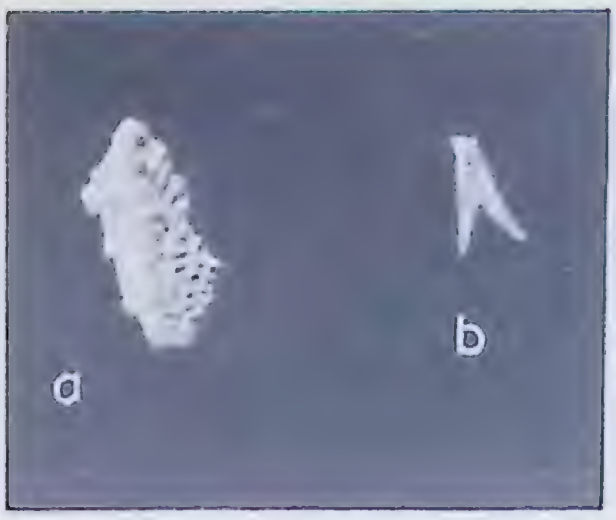
Cristivomer namaycush (Walbaum) – lake charr

Remains of this species include broken pieces of dentary and maxillary bones (Plate I, fig. 3a and b). For its nomenclature and distribution see Hubbs and Lagler (1958), Vladykov (1963), Lindsey (1964), Qadri (1964), and Tsuyuki (1965).

ESOCIDAE

Esox lucius Linnaeus – northern pike

It is represented by complete and incomplete dentaries and palatines (teeth dropped) (Plate I, fig. 4a and b), and also by an angular, subopercle, and cleithrum. For its distribution consult Smith (1954), Hubbs and Lagler (1958), McAllister (1961, 1962), and McAllister and Qadri (1965).



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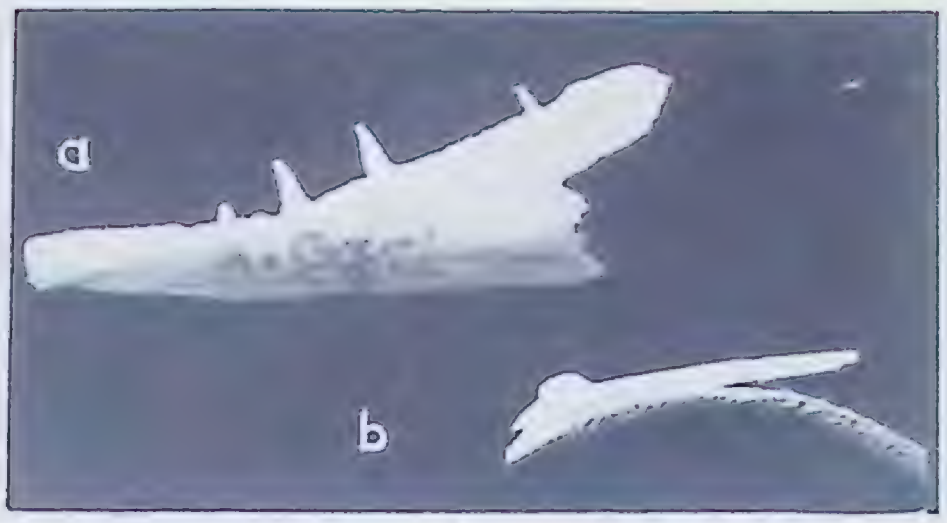

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PLATE I

Fig.

1 *Acipenser fulvescens*, a) scute, and b) fulcra

2 *Amia calva*, second postorbital

3 *Cristivomer namaycush*, a) dentary, and b) maxilla

4 *Esox lucius*, a) dentary, and b) palatine

5 *Catostomus* sp., a) maxilla, b), c), and d) pharyngeals

6 *Semotilus atromaculatus*, pharyngeal

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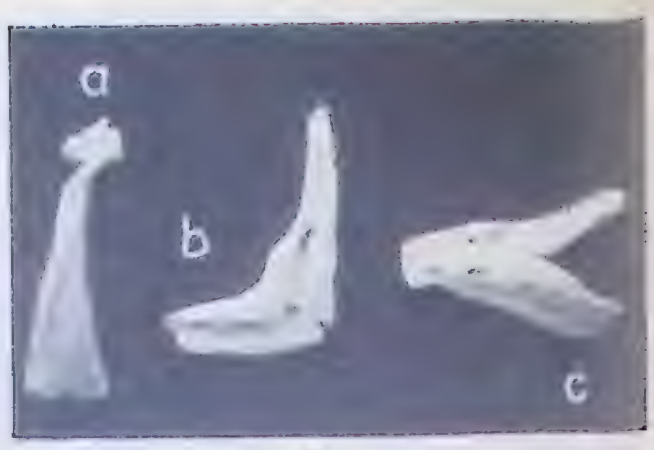

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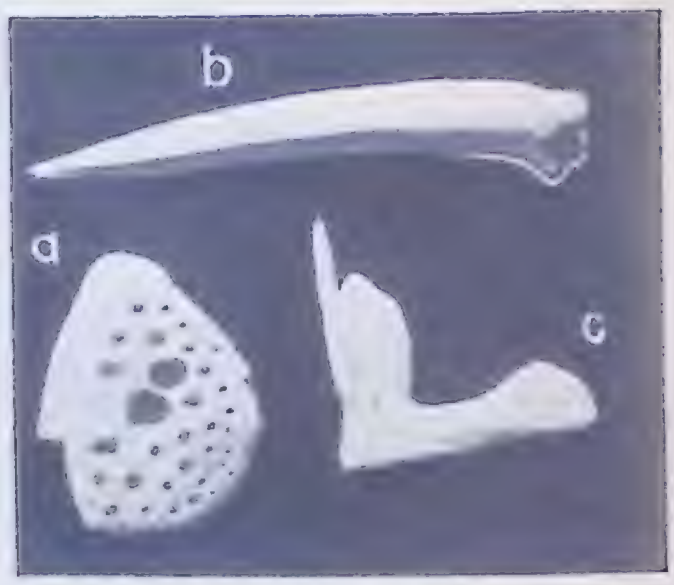

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PLATE II

Fig.

7 *Ictalurus nebulosus*, a) supraoccipital, b) pectoral spine, c) hyomandibular, and d) cleithrum

8 *Roccus chrysops*, a) maxilla, b) preopercle, and c) dentary

9 *Micropterus dolomieui*, dentary

10 *Stizostedion vitreum*, a) preopercle, b) dentary, and c) palatine

11 *Aplodinotus grunniens*, a) pharyngeal, b) spine, and c) premaxilla

CATOSTOMIDAE

Catostomus sp. – sucker

The maxilla and pharyngeal bones may belong to either of two species, *Catostomus catostomus* (Forster) or *Catostomus commersonii* (Lacépède) (Plate I, fig. 5a, b, c, and d). For its distributional records consult Hubbs and Lagler (1958) and McAllister (1959).

CYPRINIDAE

Semotilus atromaculatus (Mitchill) – creek chub

The species is recognized by the shape of the teeth on the pharyngeal arch (Plate I, fig. 6). The dental formula of the pharyngeal arch cannot be ascertained because certain teeth on the pharyngeal arch have fallen ott. For its distribution refer to Smith (1954) and Hubbs and Lagler (1958).

ICTALURIDAE

Ictalurus nebulosus (Lesueur) – brown bullhead

This species is represented by a supraoccipital, pectoral spine, hyomandibular, and cleithrum (Plate II, fig. 7a, b, c, and d). For its distribution see Hubbs and Lagler (1958) and Smith (1962).

SERRANIDAE

Roccus chrysops (Rafinesque) – white bass

The white bass is represented by the maxilla, preopercle, and dentary (Plate II, fig. 8a, b, and c), and also by a quadrate, subopercle, urohyal, and cleithrum. Consult Hubbs and Lagler (1958) for its distribution.

CENTRARCHIDAE

Micropterus dolomieui Lacépède – smallmouth bass

The species is identified by a dentary bone (Plate II, fig. 9), and also by a cleithrum and frontal. For its present distribution see Hubbs and Lagler (1958). The present site is within the range of the distribution of the species.

PERCIDAE

Stizostedion vitreum (Mitchill) – walleye

Remains of this fish include a preopercle, dentary, a portion of palatine (Plate II, fig. 10a, b, and c), an angular, and a cleithrum. For its distribution consult Hubbs and Lagler (1958), McAllister (1961 and 1962), and McAllister and Qadri (1965).

SCIAENIDAE

Aplodinotus grunniens Rafinesque – freshwater drum

The presence of this species is clearly indicated by pharyngeals, a fine spine, and a premaxilla (Plate II, fig. 11a, b, and c). For its distribution see Hubbs and Lagler (1958) and McAllister (1962).

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Number 35 *September 30, 1967*

NATIONAL MUSEUM OF CANADA **NATURAL HISTORY PAPERS**

NOTES ON THE BIOSTRATIGRAPHY OF DINOSAURIAN AND MICROFOSSIL FAUNAS IN THE EDMONTON FORMATION (CRETACEOUS), ALBERTA

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Department of the Secretary of State

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INTRODUCTION

In the course of examining fossil vertebrate collections and sediment samples from the lower portion of the Edmonton Formation of the Red Deer valley in Alberta, the authors have noted the occurrence of distinct dinosaurian and microfossil assemblages within the unit. Both authors have studied this outcrop area of the Edmonton, and the discussion of the local stratigraphy given below is the result of their mutual deliberations. Otherwise microfossil materials have been collated by Chamney, and Russell is responsible for comments relating to the dinosaurs.

The authors wish to express their gratitude to E. J. W. Irish of the Geological Survey of Canada, and C. M. Sternberg, Curator Emeritus of Fossil Vertebrates of the National Museum of Canada, for their constructive criticism of the manuscript, although the burden of the remarks that follow in no way rests upon these gentlemen. Dr. E. H. Colbert of the American Museum of Natural History and Dr. G. E. Edmund of the Royal Ontario Museum have very generously made available records and collections of Edmonton dinosaurs under their care. Special thanks are due to Drs. Paul O. McGrew of the University of Wyoming, and L.S. Russell of the Royal Ontario Museum, for providing information and photographs of *Anchiceratops* skulls in the collections of their institutions. The authors are grateful to H. L. Shearman of the National Museum of Canada for assistance in the field and to Messrs. John Neill, Sherman Tolman, Robert Tolman, and John Caswell, Alberta ranchers, who helped locate some of the old dinosaur quarries. We are also indebted to Mr. J. Anderson of Drumheller, Alberta, for pointing out the original site of the Drumheller Museum's *Pachyrhinosaurus* skull. Figures 3 to 7 were prepared by Robert Thomson of the National Museum.

HISTORY OF DINOSAUR COLLECTING

According to Lambe (1899, p. 70), T. C. Weston secured jaw fragments of a hadrosaur from the 'Laramie' of the Red Deer River in 1881. No record exists of these specimens in the National Museum, and as Weston remained in Ottawa in 1881 (Weston 1899) the reference must be in error. 1884 J. B. Tyrrell of the Geological Survey of Canada collected the skull of a carnivorous dinosaur (NMC 5600) from a light sandstone exposed on Kneehills Creek, two miles upstream from its mouth on the Red Deer River. During the latter part of June 1889, a Survey party under T. C. Weston, passing through the Edmonton badlands on the Red Deer River, recovered another camosaurian specimen (NMC 5601) from a higher horizon in the formation. Both men reported seeing broken dinosaurian bones in abundance on the exposures (see field notes preserved in the Geological Survey of Canada, Ottawa).

Presumably acting on Tyrrell's advice, Lambe set out in 1897 with an assistant down the Red Deer by boat to spend about six days prospecting the Edmonton badlands. Since none of the small amount of material he managed to collect could have been of much importance, Lambe probably was not very much impressed with his results. He continued downstream to the Oldman badlands around Steveville where he spent the remainder of the field season (see field notes preserved in the Geological Survey of Canada, Ottawa). There is no record of his Edmonton collection in the National Museum of Canada.

The attention of vertebrate palaeontologists was not brought back to the Edmonton exposures on the Red Deer River for twelve years. Mr. John L. Wegener, a wealthy Alberta cattle rancher, visited the American Museum in New York, and seeing the large bones on display in the fossil reptile hall he realized that similar bones occurred on land he had leased near the juncture of Michichi Creek and the Red Deer River. After being introduced to Barnum Brown, Wegener invited Barnum Brown to visit his home in Alberta. This Brown did in the fall of 1909 after the close of his field-work in the Hell Creek beds of Montana (see Brown in unpublished 1909 annual report of the Department of Vertebrate Paleontology, American Museum of Natural History; *see also* Brown 1911). Brown (in a letter dated October 14, 1909, on file in the American Museum) wrote enthusiastically to Osborn, President of the American Museum, that there were "literally tons of bones" weathering out on the badlands. Osborn (in a letter dated October 20, 1909, on file in the American Museum) congratulated Brown on the discovery and abmonished him not to divulge information about the rich new fossil field for the time being.

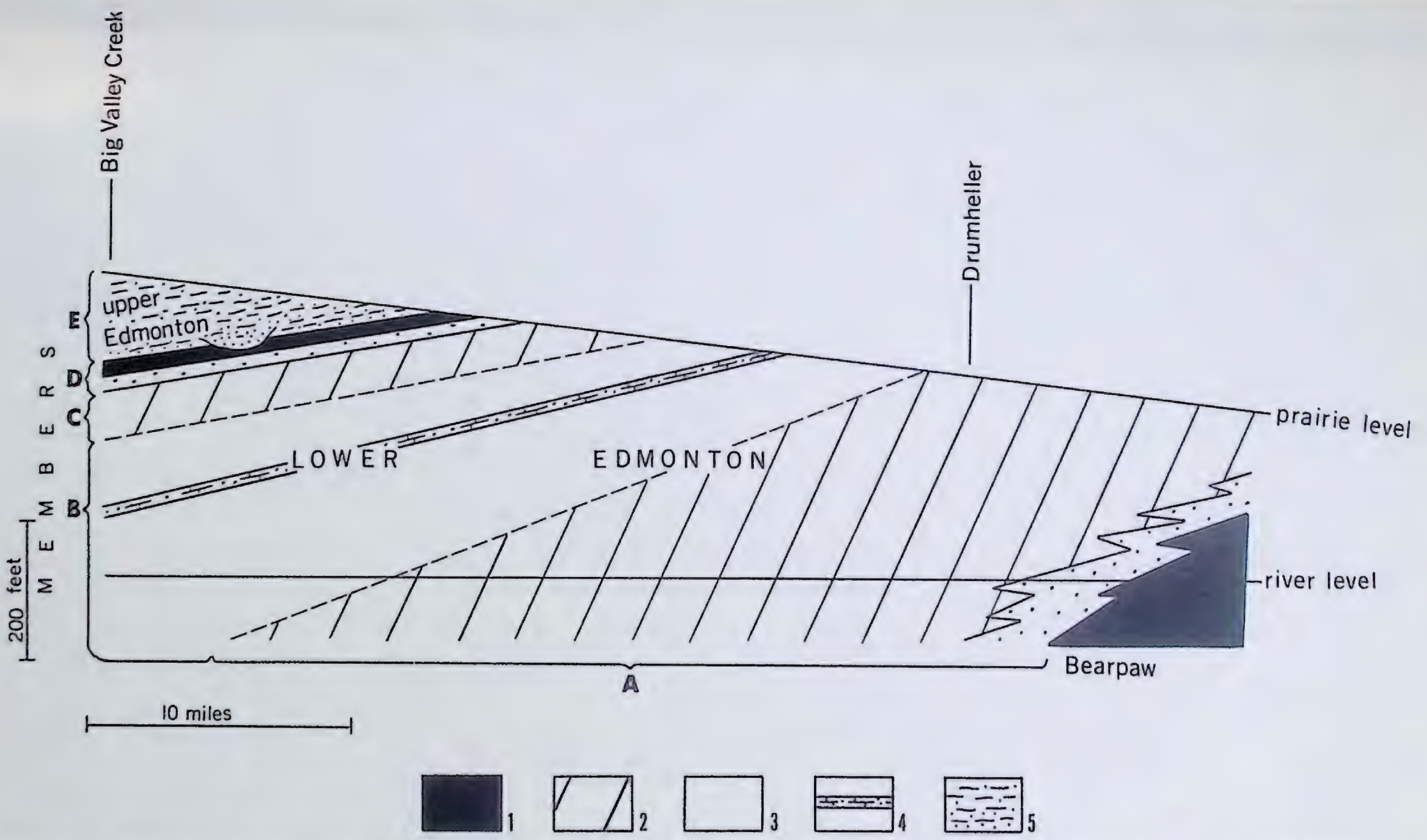

Figure 1. Relations of lower portion of Edmonton Formation, diagrammatically drawn. Big Valley Creek is located about 33 miles north of Drumheller. Lithologic facies: 1 - marine shale, 2 - coal-bearing brackish water sediments, 3 - freshwater sediments, 4 - zone of brackish water sandy limestones, 5 - more coarsely grained upper Edmonton sandstones and shales. For further explanation *see* text.

Brown (see unpublished 1910 annual report of the Department of Vertebrate Paleontology, American Museum) spent over two months collecting in the vicinity of the mouth of Big Valley Creek during the summer of 1910 and reconnoitred the remainder of the exposures of the Edmonton Formation along the river, as well as those of the Oldman Formation outcropping 90 miles farther downstream. He felt that the lower portion of the Edmonton would not yield good results because it seemed that most of the material occurred in iron stone-encrusted bonebeds; but he was very much impressed with the fossil-producing potential of the Oldman Formation. Osborn (in a letter dated October 25, 1910, on file in the American Museum) was pleased with Brown's success and again suggested that they "not go duck hunting with brass bands" (quoting O. C. Marsh) until their work in Alberta was completed. However, news of the American Museum's good fortune resulted in C. H. Sternberg's appointment to the staff of the Geological Survey of Canada, of which the National Museum was then a part, and in his appearance on the Red Deer near Drumheller by the summer of 1912. Brown (see letters to Matthew dated August 11 and September 5, 1912, on file in the American Museum), noting that the Ottawa party had been temporarily diverted by lower Edmonton bonebeds, raced to complete his work in the Edmonton and split his camp to begin taking up specimens in the richer Oldman badlands near Steveville. By 1913 both parties were competing for material in the Steveville area.

Subsequently more sustained collecting efforts were made in the Edmonton Formation by parties led by G. F. Sternberg (during the 1915 and 1916 field seasons) and later by C. M. Sternberg (1923-1926, 1946-1947 field seasons) and G. E. Lindblad (1955 field season) for the National Museum of Canada. The Royal Ontario Museum has secured a fine collection from the Edmonton through the efforts of parties led by Levi Sternberg (1922, 1931, 1933 field seasons) and G.E. Lindblad (1923-1924 field seasons).

The 5,700 man-days of hard work invested by collectors in the Edmonton Formation have produced one of the finest dinosaurian assemblages known (but easily ten times as much effort will have been expended before all the collected specimens are prepared and available for study). Some 135 specimens have been collected, including virtually complete skeletons of *Struthiomimus*, *Edmontosaurus*, *Saurolophus*, *Hypacrosaurus*, and *Anchiceratops* from the lower Edmonton, and *Thescelosaurus* and *Leptoceratops* from the upper Edmonton. The fauna could profitably be studied on a specific level, and it is hoped that the lists of specimens given below will facilitate revisory work in the future. However, enough is known of the fauna to offer some comments on the stratigraphic dispersal of forms within the lower Edmonton.

STRATIGRAPHY OF THE EDMONTON FORMATION

The Edmonton Formation, as exposed along the banks of the Red Deer River, was first described in detail by Allan (1922) and Allan and Sanderson

(1945). In it is included a sequence of about 1,200 feet of fresh and brackish water sediments unconformably overlain (Elliott 1960) by the Tertiary Paskapoo Formation and interfingering with shales of the underlying marine Bearpaw Formation. The lithologies of strata in the sequence vary considerably, both laterally and vertically. Characteristic sedimentary types include fine-grained feldspathic sandstone, sandy limestone, sandy shale, bentonitic sandstone and shale, bentonite, ironstone bands, carbonaceous shale, and coal seams. Sanderson *(in* Allan and Sanderson, 1945 p. 61) divided the formation into upper, middle, and lower members. The base of the upper member was drawn at the top of a dark shale containing the remarkably extensive Kneehills Tuff *(see* Folinsbee *et al.* 1965). As defined, the upper member is composed of about 300 feet of light-coloured sandstones and shales, with several coal seams. Sternberg (1947, p. 6) pointed out that these sediments are relatively coarser grained, more quartzose, and contain less bentonite than those below the tuff, and Ower (1960, p. 312) reported that local channel scour has downcut into and removed the dark shale-tuff beds in some localities. Both Sternberg (1947, 1949) and Bell (1949, p. 19) have shown that the terrestrial fauna and flora are significantly different above and below the base of the upper Edmonton member. More detailed stratigraphic work may one day show that this unit should be given formational status.

According to Sanderson (*in* Allan and Sanderson 1945, p. 62), the middle and lower members were separated by the Drumheller marine tongue (brackish fide Tozer 1956, p. 13), a sandy limestone containing abundant *Ostrea* and *Corbicula* shells, occurring about 600 feet above the top of the Bearpaw. However, sandy coquinoid limestone beds have been found at only one locality north of Tp. 31 along the Red Deer River (see Ower 1960, p. 311, 314; Tozer 1956, p. 13) and hence are not widely useful stratigraphic horizon markers. Observations made during the summer of 1966 suggest that this 'tongue' actually consists of a number of tongues 2 to 5 feet thick, occurring intermittently over a stratigraphic interval of at least 50 feet. These beds occur in association with similar, unfossiliferous sandy limestones, which are also resistant to erosion. Together with the coquinas, when present, the sandy limestone beds constitute a characteristic zone of ledges in exposures of the Edmonton Formation all the way from the mouth of Big Valley Creek (Tp. 34) to the north edge of Tp. 29. Primarily on Sternberg's (1949, p. 36) affirmation of the essential homogeneity of the dinosaur fauna above and below the 'Drumheller tongue' zone, but also because of the dubious lateral relations of the shell beds, most workers (eg., Elliott 1960, p. 328; L. S. Russell 1964, p. 14; Langston 1965, p. 11) have tended to recognize only an upper and a lower member in the Edmonton Formation.

Ower (1960, p. 311) has recently presented a lithologic subdivision of the sediments below the upper Edmonton member which can be more easily applied to the present study than to the bipartite subdivision originally proposed by Sanderson. Ower's members (A to D) are discussed in ascending order.

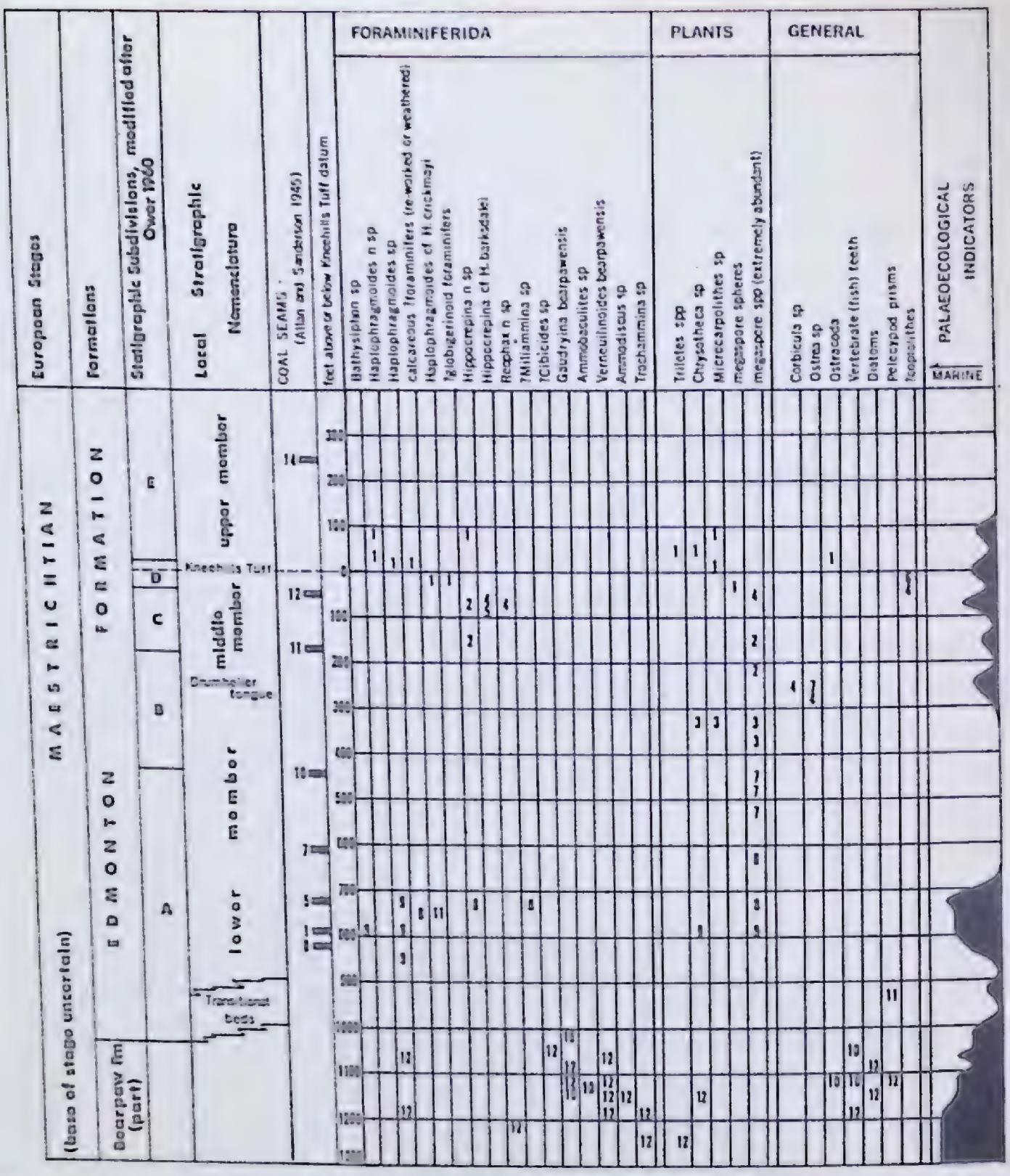

Figure 2. Microfossils recovered from the uppermost Cretaceous, Drumheller area, Alberta.

Legend for plotted sections, vicinity of Drumheller, Alberta:

(1)*	Scollard	sec. 18 tp. 34 rge. 21
(2)	Rumsey	sec. 13 tp. 33 rge. 22
(3)	Morrin	sec. 9 tp. 31 rge. 21
(4)	Horseshoe Canyon	sec. 33 tp. 28 rge. 21
(5)	Handhills	sec. 13 tp. 29 rge. 18
(6)	Gleichen	sec. 12 tp. 22 rge. 23
(7)	Horsethief Canyon	sec. 35 tp. 29 rge. 21
(8)	Rosedale	sec. 28 tp. 28 rge. 19
(9)	Bassano Dam	sec. 33 tp. 21 rge. 19
(10)*	Dorothy	sec. 4 tp. 27 rge. 17
(11)*	Willow Creek	sec. 32 tp. 27 rge. 18
(12)	Bassano	sec. 24 tp. 19 rge. 18

*Number indicates section samples collected by T. Potter Channey; remainder of section samples submitted for micropalaeontological research by E.J.W. Irish in his plains mapping project 1963 to present.

Member A is approximately 450 feet thick and contains many coal and carbonaceous shale layers. It intertongues through massive whitish lenses of sandstone with the Bearpaw Shale, which it rapidly replaces to the north and west (Ower 1960, p. 314). The top of this member is placed by Ower at the level of the Number 10 or Marker Seam of Allan (1922, p. 50). This horizon is difficult to determine exactly in the field, for the coal seams in the upper part of the member north of Tp. 29 have not been well described, and some of the stratigraphically higher coal and lignitic shale beds may be very local in extent. Nevertheless, member A is quite easily recognized. As Sanderson (*in* Allan and Sanderson 1945, p. 63) has noted, the development of sedimentary structures of deltaic origin is very noticeable in this member, particularly the lensing in and out of large, clearly defined bodies of light sandstone and darker shale and the frequent occurrence of lenses of cross-bedded sandstone. Abundant thin beds of reddish clay-ironstone, cited by Sanderson (*in* Allan and Sanderson 1945, p. 75) as evidence of intermittent stagnant ponding, are also characteristic. In contrast to the foregoing sedimentary types, individual coal seams are more laterally persistent and have been traced over relatively wide areas by Allan (1922). The flora of this portion of the formation seems to be dominated by arborescent conifers and climbing vines, although gingkos, cycads, and a peculiar arborescent angiosperm *(Trochodendroides)* are also present. Foraminiferida have been recovered from sediments 50 to 200 feet above the top of the basal transitional sands of the Edmonton. Species of *Bathysiphon, Haplophragmoides, Hippocrepina* and ?*Miliammina* are present in these sediments. No Foraminiferida have been recovered to date from the upper 250 feet of member A.

Member B has a thickness of approximately 250 feet and contains almost no carbonaeous deposits (Ower 1960, p. 311), although a few thin lignitic shale beds do occur associated with sandy coquinoid limestone (Drumheller tongue) near the middle of the member in Tp. 31. It consists mainly of pale green shale and siltstone, which become yellowish in proximity to the resistant sandy limestones. Ower (1960, p. 311) states that the sandstones are less abundant and finer textured than those in member A. Certainly the light grey lenticular sand bodies of member A are absent. Clay-ironstone is present in the form of flat, irregular nodules, but it is less common and does not occur in thin, wide bands as in member A. Of the plant localities listed by Bell (1949, p. 83) only two are undoubtedly from this portion of the section. The very imperfectly known flora seems generally similar to that of member A, but it also contains *Equisetum*. Brown (1914c, p. 366) also mentions that *Equisetum* and cycads are present at this level. No Foraminiferida have yet been recovered from the more typical greenish sediments or from the Drumheller facies of this member.

Member C resembles member A in that it contains coal seams. Its base coincides with that of the lowest coal seam above member B, and

in the valley of the Red Deer River the unit extends upward some 70 feet to the base of a white sandstone beneath the dark shale containing the Kneehills Tuff (see Ower 1960, fig. 1). The coal seams are not so extensive as those of member A (Sanderson *in* Allan and Sanderson 1945, p. 72), but they tend to recur in the same stratigraphic positions (Ower 1960, p. 312). Foraminiferida belonging to species of *Hippocrepina* and *Reophax* have been found in this member.

Member D is a very distinctive sequence of sediments lying above the highest coal (the Number 12 or Carbon Seam) of member C and below the base of the upper Edmonton member (ibid.). In the valley of the Red Deer River the lower 30 to 40 feet of the unit are composed of a relatively loosely consolidated white kaolinitic sandstone, above which is a dark bentonitic shale 15 to 30 feet thick containing the Kneehills Tuff. *Haplophragmoides* sp. occurs in the dark shale, and species of *Gümbelina* and *Haplophragmoides* are present in a correlative unit (Battle Formation) in the Cypress Hills of southeastern Saskatchewan.

The environmental significance of the succession of sediments in the Edmonton Formation is interpreted as follows (see Fig. 1). About 68 million years ago the rate of sedimentation gradually began to exceed the rate of subsidence along the western edge of the broad, shallow basin occupied by the Bearpaw sea (Folinsbee *et al.* 1965, p. 169). Beach sandstones, followed by extensive brackish water coal swamps, slowly advanced to the east (see, for example, Ower 1960; Elliott 1960) forming member A in the area of the Red Deer valley. Then, as the shoreline continued to regress toward the east, truly continental siltstones and shales (member B) were brought into and spread over earlier coaly deposits in this region. A minor transgressive pulse of the sea is indicated by the presence of thin, sandy limestone tongues, especially those containing brackish water invertebrates, in the vicinity of Drumheller, near the middle of member B. Then the rate of subsidence relatively rapidly overtook the rate of sedimentation, bringing a thinner coal zone (member C) back into the area of the Red Deer valley, and behind it kaolinite beach sands and thin bentonitic shales (member D). The Kneehills Tuff was deposited some 66 million years ago (*ibid.*, p. 174), at which time the sea had spread over the Edmonton wedge of fresh and brackish water sediments. Similar vertical and horizontal associations of sedimentary types occur frequently in the late Cretaceous of the western interior of the United States (see, for example, Spieker 1949). After a rather lengthy interlude, during which sedimentation nearly ceased (dark shale of member D), the relatively coarser clastics of the upper Edmonton member were swept in over the area. Upper Cretaceous deposition ended with the extinction of the Lancian *Triceratops* fauna about 64 million years ago (Folinsbee *et al.* 1965, p. 174).

DINOSAUR FAUNA OF THE EDMONTON FORMATION

The Red Deer River cuts a valley 300 to 500 feet deep into Edmonton sediments as it flows in a generally south by southeasterly direction from

the mouth of Tail Creek to Drumheller. An essentially continuous strip of badlands, averaging one-half mile in width, is present on each side of the valley for 45 miles north of Drumheller. Nearly all the dinosaurian specimens known from the Edmonton Formation have been collected from these badlands. The river tends to follow the strike of the beds in this region, and, because the river level drops at about the same rate as the prairie level, successively older strata are exposed along the valley walls as the river flows southward.

Brown (1914c) published a good general description of the Edmonton Formation as it outcrops in the Red Deer valley, but he stated that the unit was faunistically indivisible. Gilmore (1924*b*, p. 63) doubted whether horizons in the Edmonton could ever be distinguished on the basis of their dinosaurian assemblages. However, Sternberg (1947, 1949) was able to demonstrate the distinctiveness of the upper Edmonton member largely because of its characteristic Lancian dinosaur fauna. The lower Edmonton (members A - D of Ower) has universally been regarded as a faunal unit, although Sternberg (1926, p. 103) long ago noted a peculiar geographical distribution of hadrosaurian genera along the banks of the Red Deer, with hooded or crested forms occurring only in the northern half of the outcrop area and flat-headed forms prevailing in the southern half. This curious fact provided the stimulus for the present study.

During the winter of 1965-1966 the senior author visited the American Museum of Natural History in New York and the Royal Ontario Museum in Toronto to become familiar with their collections of Edmonton dinosaurs. With the exception of the missing collections of Lawrence Lambe (made in 1897) and Alexander MacLean (made in 1912), of the University of Toronto neither of which apparently contained cranial or otherwise important material (Fritz 1939, p. 8), and of recent collections of the University of Alberta, an inventory has been made of all dinosaur specimens taken from Edmonton strata together with the data on their respective occurrences. For a three weeks' period during the summer of 1966, exposures of the Edmonton were studied in the area under consideration. It was usually impossible to locate quarries without the help of old photographs or local ranchers. Quarries made in siltstone or shale prior to 1935 have generally been so badly weathered as to be unrecognizable, and at least three to four inches of hard white sandstone have been lost to erosion in one quarry made in 1916. Only eighteen old dinosaur quarries were relocated. However it was relatively easy for collectors to measure the elevation above the river at which a particular specimen occurred and to locate the site with respect to a ferry, ranch house, or land survey divisions. Locality data are usually good, and because of the linear arrangement of exposures along the river it has been relatively easy to determine the approximate horizon in the formation from which any given specimen has been taken.

All the dinosaurian material from the lower Edmonton can be assigned to either members A or B of Ower. No dinosaur remains have yet been

collected from members C or D, although they may be present there also. In compiling the faunal lists, bonebed material, long known to collectors as being more abundant in member A, has not been included. Interestingly, dinosaur bonebeds have been reported within the coal seams (Allan 1922; Allan and Sanderson 1945) as well as in association with the more usual sedimentary types. The sedimentary significance of bonebed deposits has never been studied. Collectors have tended to bypass them because they contain so little good articulated material. Isolated postcranial elements (except AMNH 5225) have also been omitted so that only articulated postcranial or cranial material is represented in the lists. Langston (1959, p. 6) points out that the collections may be biased in favour of good display specimens. A perusal of the field notes suggests that at least prior to 1920 this was not so. After 1920 probably every ornithomimid, tyrannosaurid, and nodosaur specimen seen was collected unless it was nearly destroyed by erosion. However if a hadrosaur skeleton, or less frequently one of a ceratopsian, was not well preserved, it was left behind. Thus hadrosaurs and, to some extent, ceratopsians are not so well represented in these lists as they are in the sediments.

Only holotypic specimens have a specific designation in the lists; all others have been assigned to a generic or higher category. Many specimens do not have a catalogue number. Usually these are unprepared, and only the field number is given, preceded by the year in which the specimen was collected and the initials of the collecting institution. Although the American Museum of Natural History (abbreviated AMNH), the National Museum of Canada (NMC), and the Royal Ontario Museum (ROM) were until recently the only institutions to have collected dinosaurs from the Edmonton Formation, specimens have been traded to several other museums. In most cases these specimens are identified in the same manner as unprepared specimens, in parentheses following the name of the new possessor. The letters UW refer to a specimen in the collections of the University of Wyoming.

FAUNAL LIST, MEMBER A

Family ORNITHOMIMIDAE

Ornithomimus brevitertius (Parks 1926): ROM 797.
Ornithomimus edmontonicus Sternberg 1933: NMC 8632.
Ornithomimus currelli (Parks 1933): ROM 851.
ornithomimid, undet: NMC 1923-5, ROM 1923-1.

Family TYRANNOSAURIDAE

Albertosaurus sarcophagus Osborn 1905: NMC 5600.
Albertosaurus arctunguis Parks 1928: ROM 807.
tyrannosaurid, undet: NMC 1912-5.

Family HADROSAURIDAE

Subfamily HADROSAURINAE

Edmontosaurus regalis Lambe 1917: NMC 2288.
Edmontosaurus edmontoni (Gilmore 1924): NMC 8399.
Edmontosaurus sp: AMNH 5254; NMC 2289, 1923-4, 1924-4; ROM 658, 792, 801, 867, 1924-2; specimens in British Museum (Natural History) (NMC 1923-3, 1955-4); Carnegie Museum (ROM 1931-7); Chicago Natural History Museum (ROM 1933-3); Drumheller Museum, Alberta (NMC 9871, 9872); Museum of Natural History, Buenos Aires, Argentina (ROM 1923-6); U.S. National Museum (ROM 1931-4).
hadrosaurine, undet: AMNH 5271, 5277.
hadrosaurid, undet: AMNH 5275, 5276; NMC 1912-7, 1912-31, 1912-32, 1916-7, 1916-10, 1916-12, 1955-3; ROM 1922-3, 1923-7, 1933-2; specimen in Museum of Natural History, Buenos Aires, Argentina (ROM 1924-3).

Family PACHYCEPHALOSAURIDAE

Stegoceras sp: NMC 11316.

Family NODOSAURIDAE

Subfamily ANKYLOSAURINAE

Anodontosaurus lambei Sternberg 1929: NMC 8530.

ankylosaurine, undet: ROM 5405.

Subfamily PANOPLOSAURINAE

Edmontonia longiceps Sternberg 1928: NMC 8531.

nodosaurid, undet: specimen in U.S. National Museum (NMC 1916-8).

Family CERATOPSIDAE

Anchiceratops sp: AMNH 5273; NMC 10681; ROM 802; UW 2419; specimen in Chicago Natural History Museum (ROM 1933-1).
Arrhinoceratops brachyops Parks 1925: ROM 796.
Arrhinoceratops sp: ROM 1439.

ceratopsid, undet: NMC 1955-2.

Family PACHYRHINOSAURIDAE

Pachyrhinosaurus sp: specimen in Drumheller Museum, Alberta.

FAUNAL LIST, MEMBER B

Family ORNITHOMIMIDAE

Ornithomimus ingens (Parks 1933): ROM 852.

ornithomimid, undet: AMNH 5201, 5255, 5257, 5262, 5264, 1910-2; NMC 1924-1, 1926-5, 1926-6, 1926-7; specimen in Regina Museum, Saskatchewan (NMC 1916-3).

Family TYRANNOSAURIDAE

tyrannosaurid, undet: AMNH 5218, 5222; NMC 5601, 11315.

Family HYPSILOPHODONTIDAE

Parksosaurus warreni (Parks 1926): ROM 804.

Family HADROSAURIDAE

Subfamily HADROSAURINAE

Edmontosaurus sp: NMC 8744.

Subfamily SAUROLOPHINAE

Saurolophus osborni Brown 1912: AMNH 5220.
Saurolophus sp: AMNH 5202, 5221; NMC 8796, 1926-4.

Subfamily LAMBEOSAURINAE

Cheneosaurus tolmanensis Lambe 1917: NMC 2246.
Cheneosaurus sp: AMNH 5256; NMC 2247, 8673, 8674, 1925-3.
Hypacrosaurus altispinus Brown 1913: AMNH 5204.
Hypacrosaurus sp: AMNH 5200, 5206, 5212, 5217, 5225, 5248, 5253, 5272, 5278; NMC 8501, 8675, 1926-3; ROM 702, 789, ?1438.

hadrosaurid, undet: AMNH 5209, 5219, 5242, 5243, 5250, 5258; NMC 1915-3, 1915-11, 1915-15, 1915-17, 1915-19, 1916-1; specimens in Redpath Museum, Montreal (NMC 1916-2); Regina Museum, Saskatchewan (NMC 1916-4).

Family PACHYCEPHALOSAURIDAE

Stegoceras edmontonensis (Brown and Schlaikjer 1943): NMC 8830.
Stegoceras sp: NMC 8831, 8832.

Family NODOSAURIDAE

Subfamily ANKYLOSAURINAE

ankylosaurine, undet: AMNH 5223.

nodosaurid, undet: AMNH 5211, 5216, 5245, 5249, 5266; NMC 1915-18.

Family CERATOPSIDAE

Anchiceratops ornatus Brown 1914: AMNH 5251.
Anchiceratops longirostris Sternberg 1929: NMC 8535.
Anchiceratops sp: AMNH 5246, 5259; NMC 8547, 9577, 10682, 1916-14, 1924-10.
Arrhinoceratops sp: NMC 8882.

ceratopsid, undet: AMNH 5260, 5263, 5265; NMC 1924-3.

PLESIOSAURIA

Leurospondylus ultimus Brown 1913: AMNH 5261.
elasmosaurid, undet: NMC 9454.

It is evident that hadrosaurs significantly outnumber all other kinds of dinosaurs in the lower Edmonton. Further, member A is characterized by the abundance of *Edmontosaurus*, and member B by the association of *Saurolophus, Cheneosaurus*, and *Hypacrosaurus*. There are two exceptions: AMNH 5272, a paratype of *H. altispinus*, comes from an elevation that would seem to place it in member A, but there are slumped strata from member B in the vicinity of the locality and the exact stratigraphic position of the specimen is uncertain; NMC 8744, *Edmontosaurus* sp., comes from a horizon 30 to 40 feet above the highest lignitic layer in member A, but the occurrence may be regarded only as an exception to a rule.

It would seem then that *Edmontosaurus* preferred environments in the vicinity of coniferous forests, associated with brackish water coal swamps, and in areas of a rather strongly deltaic nature. Interestingly, Kräusel (1922) has described the stomach contents of an *Anatosaurus*, a genus very closely allied to *Edmontosaurus*, as consisting predominantly of conifer needles. On the other hand, *Saurolophus, Cheneosaurus*, and *Hypacrosaurus* must have preferred marginal lowlands of a more continental facies. The latter forms all have progenitors in similar association *(Prosaurolophus, Procheneosaurus*, and *Corythosaurus)* within the freshwater sediments of the Oldman Formation, where no generalized hadrosaurines are known to have occurred. Although the hooded and crested forms stratigraphically overlie the flat-headed hadrosaurs within the Edmonton Formation, it must be emphasized that the factor controlling the distribution of hadrosaurs is environment, not time.

Anchiceratops, a moderately large, horned dinosaur, is the most abundant ceratopsian in the lower Edmonton. Some fourteen specimens, all but one lacking postcranial remains, have been collected. They range in stratigraphic position from about 120 feet above the highest lignitic layer in member A (NMC 8547) to about 120 feet below it (ROM 802). Langston (1959, p. 7, fig. 2), following Sternberg (1929, p. 34), has suggested that *Anchiceratops* tends to be most abundant in the zone of the ledge-forming sandy limestones (Drumheller tongue), or approximately in the middle of coal-free member B. This postulation was based on observations of uncollected ceratopsian specimens in the field. However, the precise stratigraphic position of these specimens was never noted, and the field impression is not at all borne out by an inspection of locality data with collected specimens. The latter information does not suggest that *Anchiceratops* is more common at any particular horizon in the stratigraphic interval over which it is known to occur. Because the animal appears to have been about as abundant in the coaly upper portion of member A as it was in the lower half of member B, it was evidently somewhat more euryopic in its environmental requirements than has been suspected.

Figure 3. Skull of *Anchiceratops,* restored primarily after NMC 8535 and NMC 10681 but in part after AMNH 5251 (Brown 1914a, pl. 29A) and ROM 802. The proportions are those of NMC 8535.

With the possible exception of the type specimen of *Albertosaurus sarcophagus*, no articulated dinosaur has been collected below a horizon 150 feet under the highest lignitic layer of member A. This may be because of the disposition of these sediments too far off the seaward edge of the alluvial plain for large primarily terrestrial animals to venture, or because of the development of impenetrable coal swamps. The vertical range over which articulated dinosaurs are known corresponds very closely to that portion of the section in which Foraminiferida are presently unknown.

Two nearly complete plesiosaur skeletons have been collected from the zone of the ledge-forming sandy limestones in member B. Considering the local occurrence of brackish water molluscs, the plesiosaurs must have been tolerant of changes in salinity (see L.S. Russell 1931) and therefore may be taken as evidence of the existence of local bodies of moderately deep water in communication with the open sea during the deposition of the middle portion of the member. Perhaps plesiosaurs, occasionally trapped in small pools by subsiding storm or tidal waters, died there.

COMMENTS ON DINOSAURIAN NOMENCLATURE

Gilmore (1924*a*) described a new species of flat-headed hadrosaur from the lower Edmonton and referred it to a genus distinct from *Edmontosaurus*. *Thespesius edmontoni* (NMC 8399) was separated from *Edmontosaurus regalis* principally on the bases of the smaller size of the pocket-like recess in the postorbital, the greater length of the radius as compared with that of the humerus, and a longer skull relative to the height of the quadrate. The skeleton was mounted on its right side in 1913 so that the right humerus is no longer visible in its entirety. In any case its distal end has been restored, and it is difficult to see how Gilmore was able to estimate its original length. The left humerus may also have been restored distally; but as mounted, it exceeds the radius in length by about two inches. The ratio between the height of the quadrate and the length of the skull is variable in flat-headed Edmonton hadrosaurs, and evidence has not been presented that this variation is not unimodal.

Lull and Wright (1942, p. 154) proposed the new genus *Anatosaurus* for the reception of several species of flat-headed hadrosaurs of Lancian age and *Anatosaurus (Thespesius) edmontoni* from the lower Edmonton. *Edmontosaurus* was distinguished from *Anatosaurus* (ibid., p. 155) by the 'tumid' appearance of the premaxillary beak, by the separation of the squamosals posteriorly by a median tongue of the parietal, by the absence of as incipient dome in the frontal region between the orbits, and by a greater number of tooth rows in the dentary. If *Anatosaurus* is indeed generically separable from *Edmontosaurus*, then *"A." edmontoni* should be included in the latter genus, for, although the number of tooth rows in the dentary cannot be ascertained, the other characters cited above as diagnostic of *Edmontosaurus* are present in the skull of NMC 8399. The type skull of *E. regalis* is very large, and it may be that the differences existing between

Figure 4. Skull of *Edmontosaurus*, lateral aspect, after specimen in British Museum (Natural History) (formerly NMC 1955-4).

it and other specimens of flat-headed hadrosaurs in the lower Edmonton are due to growth allometry or individual variation.

The distal end of the ischium is missing in the type skeleton of *Saurolophus osborni* (AMNH 5220), and Brown (1913*a*, p. 387) considered a complete but isolated ischium (AMNH 5225) as typical of the element in this species. The ischial shaft of this specimen is compressed; it expands abruptly into a heavy foot distally, very much resembling the ischium of *Hypacrosaurus*, as Lull and Wright (1942, p. 177) have pointed out. Sternberg (1953, p. 10; 1954, p. 382), noting the absence of a distinct foot at the distal end of the ischium in *Prosaurolophus*, predicted that a similar condition would exist in *Saurolophus* when pelvic and cranial material were found in association. Rozhdestvensky (1957) demonstrated that this was indeed the case in a complete skeleton of *Saurolophus angustirostris*, a closely related species from the late Cretaceous of Mongolia.

An ischium belonging to an undescribed pelvis and sacrum (AMNH 5202) from the lower Edmonton differs from that of the type of *Hypacrosaurus altispinus* (AMNH 5204) and that of AMNH 5225 in that the ischial shaft is narrower, lacks any suggestion of a slightly sigmoidal appearance in lateral aspect, and gradually dilates into a distal expansion about intermediate in development between the condition found in lambeosaurines and hadrosaurines. The proximal portion of the ischium in this specimen is morphologically identical to the same portion of the element in the type of *S. osborni*. The plesiotype ischium of *S. osborni* (AMNH 5225) should therefore be referred to *H. altispinus*, and the ischium of AMNH 5202 is in all probability representative of the element in *Saurolophus osborni*.

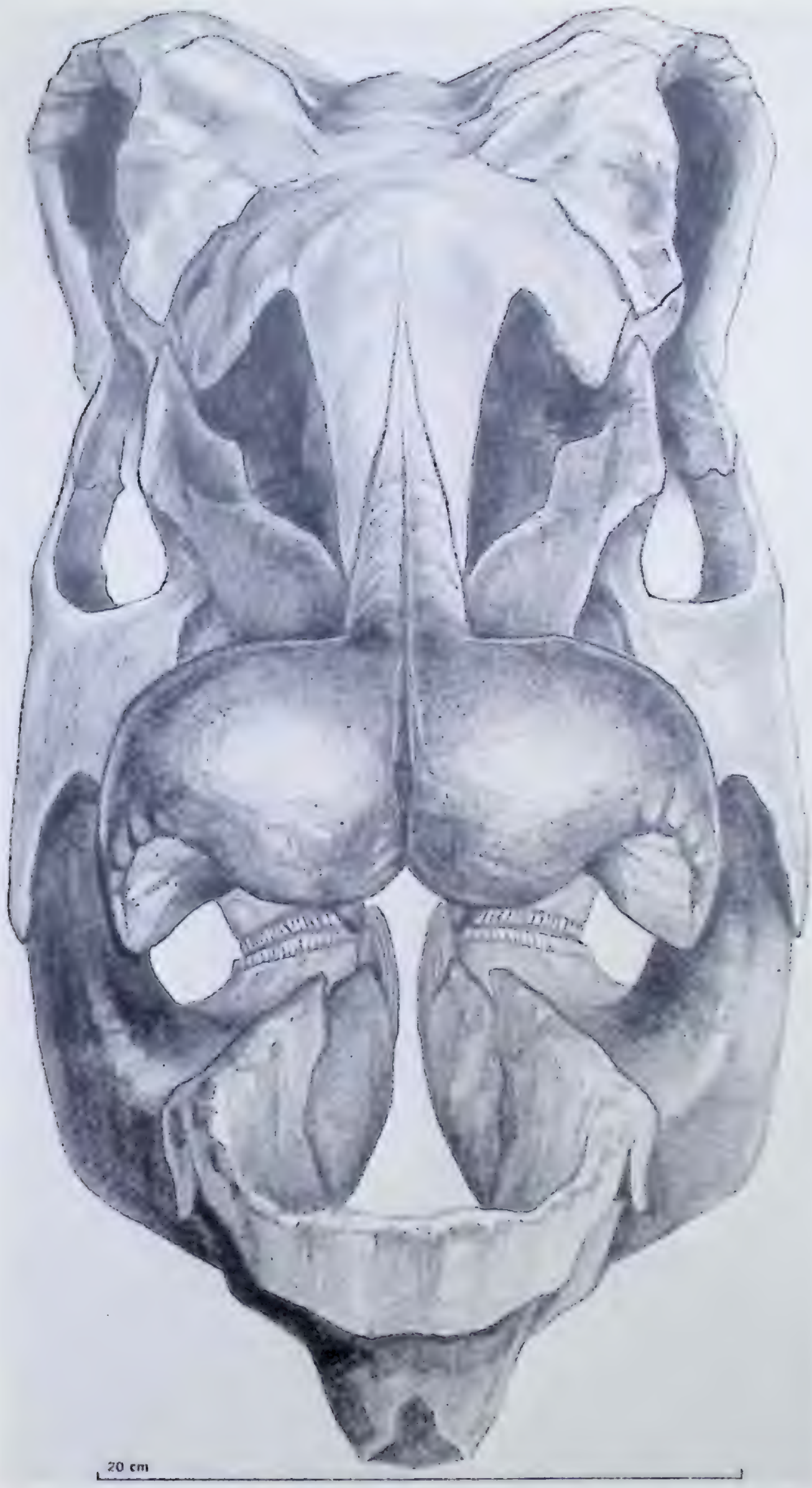

Figure 5. Skull of *Edmontosaurus*, anterior aspect, after specimen in British Museum (Natural History) (formerly NMC 1955-4). Distortion has been removed from the beak and muzzle area, and the anterior rim of the predentary is largely restored.

Figure 6. Skull of *Saurolophus*, lateral aspect, restored after NMC 8796 and AMNH 5220 (Brown 1912, fig. 1). The proportions are those of NMC 8796.

Figure 7. Skull of *Saurolophus*, anterior aspect, after NMC 8796.

Excellent photographs of the relatively well-preserved type skull of *Anchiceratops longirostris* (NMC 8535) have been published by Sternberg (1929b, pls. 11, 12) and Lull (1933, pl. 10). However, this skull has suffered some dorsoventral crushing, and the more ventral elements have been damaged or lost through erosion. It is hoped that the reconstruction of the skull presented here (Fig. 3) will be of some use. The suspensorium and the lateral rim of the squamosal have been restored after those of the type of *A. ornatus* (Brown 1914*a*, pl. 29A). The general shape of the external nares and the premaxillo-maxillary and premaxillo-nasal sutures are as preserved in a laterally compressed rostrum (NMC 10681), and the antorbital region and the posterior rim of the external nares are as in ROM 802. *Anchiceratops longirostris* differs from the generotypic *A. ornatus* perhaps most significantly in that the brow horns of *A. longirostris* are relatively shorter, more slender, and less divergent laterally. Another small skull of *Anchiceratops* (UW 2419) has brow horns similar to the type and paratype of *A. ornatus*. The more slender horns of the type of *A. longirostris* cannot then be entirely related to its possible state of maturity. The supranarial ramus of the nasal appears to be more strongly bowed anteroventrally in ROM 802 than in NMC 8535 and NMC 10681. The brow horns of the Toronto specimen are quite heavy, and if it can be referred to *A. ornatus* it may be that the latter species did indeed have a shorter snout than *A. longirostris*.

SUMMARY

The lower member (*sensu* Bell 1949, or members A to D of Ower) of the Edmonton Formation in the Red Deer valley is recognized as an essentially symmetrical sequence of sedimentary facies bounded above and below by marine shales. The sequence begins with beach sands at the base of the formation, and these are overlain by brackish water coal-bearing deposits and then freshwater siltstones and shales. The sequence is then reversed, although the sedimentary facies are thinner in the upper portion of the lower Edmonton. Foraminiferida occur within every sedimentary facies except the freshwater deposits in the centre of the sequence. *Edmontosaurus* is the only hadrosaur known to occur in the lower coal-bearing strata, whereas *Cheneosaurus*, *Hypacrosaurus*, and *Saurolophus* occur in the central freshwater facies. *Anchiceratops* occurs in association with both hadrosaurian faunas.

Anatosaurus edmontoni is referred to the genus *Edmontosaurus*, and a pelvis bearing a slender ischium with a slightly expanded distal end is referred to *Saurolophus*. Also reconstructions are presented of the skulls of some typical lower Edmonton dinosaurs.

REFERENCES

An attempt has been made to include references to all the more important descriptions of Edmonton dinosaurs, as well as those cited in the text. Annotations have been made to clarify the contents of a few of the papers.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

A CENSUS OF DINOSAUR SPECIMENS COLLECTED IN WESTERN CANADA

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Department of the Secretary of State

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A Census of Dinosaur Specimens Collected in Western Canada

D. Russell

INTRODUCTION

At different intervals during late Cretaceous time, floodplains were built from the eastern base of the Cordilleran ranges far out into the epicontinental sea which then covered the Prairie Provinces of Canada. These floodplain deposits, as exposed in the badlands of Alberta and Saskatchewan, have yielded the finest sequence of dinosaurian assemblages known. Recently I have had the opportunity of visiting the major collections of western Canadian dinosaurs. Lists were made of all the specimens of dinosaurs that have been collected from the most important localities. They are presented here to serve as a complement to faunal lists already available (L. S. Russell 1964, Langston 1965) in forming an understanding of the composition of dinosaur faunas inhabiting western Canada during the closing phases of Cretaceous time.

I have enjoyed the fullest possible co-operation of Dr. A. J. Charig of the British Museum (Natural History), Dr. E. H. Colbert of the American Museum of Natural History, Dr. A. G. Edmund of the Royal Ontario Museum, and Dr. R. C. Fox of the University of Alberta, in obtaining access to the collections and field records of their respective institutions. It is indeed a pleasure to acknowledge the courteous assistance of these gentlemen. I am also grateful to Dr. L. S. Russell of the Royal Ontario Museum for data relating to specimens collected from the Frenchman Formation, and to Mr. David Techter for information on Canadian dinosaurs in the collections of the Field Museum of Natural History in Chicago. Dr. Colbert has very kindly proofread the manuscript and offered several suggestions which have clarified some of the points made below.

PROCEDURE

As considered here, a 'specimen' represents articulated skeletal material belonging to a single individual. Thus material varying in completeness from two articulated bony elements to entire skeletons is included in the lists, but not isolated bones or most of the material occurring in bonebeds.

Based on counts of specimens collected by the different field parties the lists reflect a sampling bias in favour of the better-preserved or morphologically unusual specimens (see also Langston 1959*b*: 6). It must be remembered that commoner types of dinosaurs from a given locality are under-represented in the lists, while the reverse is true of rarer forms. A study of the field records of the American Museum of Natural History and the National Museum of Canada indicates that hadrosaur and, to a lesser extent, ceratopsian remains, if poorly preserved, were frequently left behind by collectors working in the Oldman Formation and in the lower members of the Edmonton Formation. Perhaps the actual number of hadrosaurs encountered in these sediments would exceed the number collected by a factor of about two. Poorly preserved *Triceratops* specimens were evidently more frequently bypassed than those of hadrosaurs in deposits of Lancian age (see field records of the National Museum of Canada; Brown 1907: 841, 1917: 281). With these biases in mind, a census of all the specimens collected by the different institutions may provide a surer estimate of the natural abundance of dinosaurian forms in the sediments than that provided by trusting to the memory of individual collectors.

Prepared specimens of Canadian dinosaurs in the American Museum of Natural History, the British Museum (Natural History), the National Museum of Canada, the Royal Ontario Museum, and the University of Alberta were identified to the family level, or in some cases to a subfamilial or even generic rank. The lack of adequate systematic studies precluded more precise determinations. Since collecting institutions have kept records of materials sent to other museums, these have been consulted regarding the identification of exchanged specimens. In the case of unprepared materials, the general field identification of the collector has been accepted. Unpublished sources of information include field notes in the above-mentioned institutions, letters of C. H. Sternberg and B. Brown on file in the American Museum of Natural History, and the annual reports of the Division of Vertebrate Paleontology in the Osborn Library of the American Museum. Specimens purchased from W. E. Cutler are identified as having been collected by him in the catalogues of the British Museum (Natural History). As the field records of the Field Museum's expedition to Alberta in 1922 have been lost (pers. comm. Techter 1966), it was necessary to compile the specimen list from the Annual Report of the Field Museum for 1922. It is believed that very few dinosaurian specimens taken from the more important localities of western Canada are omitted from the list given below.

It will take many years to prepare and study all the specimens collected in Alberta and Saskatchewan since Brown began his work on the Red Deer River in 1910 (see L.S. Russell 1966). For the present it is hoped that this preliminary census will prove to be of value.

MILK RIVER FORMATION

The Milk River Formation* of southern Alberta has produced the oldest known remains of late Cretaceous dinosaurs in Canada. Fragmentary bones and teeth of ornithomimids, tyrannosaurids, hadrosaurids, pachycephalosaurids, nodosaurids, and ceratopsians have been identified, some of which may belong to forms unknown in higher horizons (L. S. Russell 1935, 1964). All the material is from bonebed deposits.

OLDMAN FORMATION

Following an interval of marine (Pakowki Shale) and brackish water (Foremost Formation) sedimentation, the sandstones and shales of the Oldman Formation represent the next period of non-marine deposition in the western plains. This unit is well exposed along the Red Deer River in south-central Alberta (Steveville locality) where it has been intensively prospected. Sternberg (1950*a*) relocated many of the sites from which specimens had been excavated and found that the quarries were spread over a vertical interval of about 200 feet. The large fauna is characterized by a preponderance of lambeosaurine hadrosaurs and the relative abundance of short-squamosalled ceratopsians (*Centrosaurus, Monoclonius, Styracosaurus*). Certain forms considered typical of Oldman ('Belly River') strata, such as *Parasaurolophus* and *Styracosaurus*, are actually quite rare. The former genus is represented by a single specimen (ROM 768), and the latter by only two relatively complete specimens (AMNH 5372, NMC 344). Similarly, only one specimen of *Brachylophosaurus* (NMC 8893) is known from these deposits. Isolated water-worn skulls of the peculiar pachycephalosaurs (*Stegoceras*) have been recovered in some abundance, and in one instance cranial and postcranial remains were found in association (Gilmore 1924). Langston (1959a: 12) notes that similar crania are also relatively abundant in the underlying brackish water deposits of the Foremost Formation along Chin Coulee in south-central Alberta. Whatever the ecological requirements of these odd dinosaurs may have been, the skulls were carried by running water into a variety of sedimentary environments.

The occurrence of the ceratopsian genera *Centrosaurus* and *Monoclonius* together in the Oldman Formation of the Red Deer River is here recognized for the first time. The two genera were synonymized by Brown (1914), although Lull (1933: 81-82) considered them to be distinct at a subgeneric level. Lull (ibid.) suggested that *Monoclonius* was confined to the Judith River Formation of Montana and *Centrosaurus* to the correlative Oldman

*For a comprehensive review of the late Cretaceous stratigraphy of Western Canada, see Williams and Burk 1966.

Formation of Alberta. Sternberg (1938, 1940) was able to clearly separate *Centrosaurus* from *Monoclonius* largely on the basis of cranial material of the latter genus that he had collected from the Oldman Formation in southeastern Alberta. He also demonstrated the presence of *Centrosaurus* in the Judith River Formation by referring the type of *"Monoclonius" recurvicornis* to this genus. Briefly, *Monoclonius* may be distinguished from *Centrosaurus* by the absence of hook-like processes on the posterior border of its thin parietal frill, the smoothly surfaced instead of rugose bone bordering the anterodorsal corner of the orbits, and the compressed, posteriorly recurved nasal horn, which is separated into two halves by a distinct longitudinal suture. The collections of the American Museum of Natural History contain an especially fine skull of *Monoclonius* (AMNH 5442) from the Oldman Formation of the Red Deer River. Several other specimens of the genus from this locality were recognized in the collections of other institutions.

DINOSAURIAN SPECIMENS COLLECTED FROM THE OLDMAN FORMATION (BELLY RIVER) IN THE VICINITY OF STEVEVILLE, ALBERTA

	Number of specimens	Percentage of fauna
Family COELUROSAURIDAE	6	1.9
Family ORNITHOMIMIDAE	19	5.9
Family TYRANNOSAURIDAE	24	7.5
Family HADROSAURIDAE	134	41.8
Subfamily HADROSAURINAE *(Gryposaurus, Kritosaurus)*	9	2.8
Subfamily SAUROLOPHINAE *(Brachylophosaurus, Prosaurolophus)*	9	2.8
Subfamily LAMBEOSAURINAE *(Corythosaurus, Lambeosaurus, Parasaurolophus, Procheneosaurus)*	72	22.5
subfamily undetermined	44	13.7
Family PACHYCEPHALOSAURIDAE	25	7.8
Family NODOSAURIDAE	35	10.9
Subfamily ANKYLOSAURINAE	9	2.8
Subfamily PANOPLOSAURINAE	5	1.6
subfamily undetermined	21	6.6
Family CERATOPSIDAE	77	24.0
Centrosaurus	22	6.9
Chasmosaurus	20	6.3
Monoclonius	5	1.6
Styracosaurus	5	1.6
genus undetermined	25	7.8
TOTAL	320	

A little over a dozen specimens of dinosaurs have been collected from exposures of the Oldman Formation on the western flanks of the Cypress Hills in southeastern Alberta. The two fragmentary *Anchiceratops* frills described by Langston (1959*b*) came from the highest levels of the Formation in this region. It is a well-known fact that genera of ceratopsian dinosaurs are usually restricted to single intervals of non-marine deposition in the Cretaceous of Alberta. The occurrence of *Anchiceratops* in the Oldman Formation of the Cypress Hills and in the lower members of the Edmonton Formation along the banks of the Red Deer River some 125 miles to the northwest is an important exception to this rule (see Langston, ibid.).

LOWER EDMONTON FORMATION

After another interval of marine deposition (Bearpaw Shale), brackish and freshwater sediments of the lower Edmonton Formation were deposited far out into the interior sea in central Alberta. Most of the dinosaur remains from this formation have been collected from the strips of badlands lining the shallow canyon of the Red Deer River between Scollard and Drumheller. These exposures have generally been considered less rich in dinosaurian material than those of the Oldman Formation further downstream. However

DINOSAURIAN SPECIMENS COLLECTED FROM THE EDMONTON FORMATION (MEMBER A) ALONG THE RED DEER RIVER, ALBERTA

	Number of specimens	Percentage of fauna
Family ORNITHOMIMIDAE	5	9.1
Family TYRANNOSAURIDAE	3	5.5
Family HADROSAURIDAE	33	60.0
Subfamily HADROSAURINAE (*Edmontosaurus*)	20	36.4
subfamily undetermined	13	23.6
Family PACHYCEPHALOSAURIDAE	1	1.8
Family NODOSAURIDAE	4	7.3
Subfamily ANKYLOSAURINAE	2	3.6
Subfamily PANOPLOSAURINAE	1	1.8
subfamily undetermined	1	1.8
Family CERATOPSIDAE	9	16.4
Anchiceratops	5	9.1
Arrhinoceratops	2	3.6
Pachyrhinosaurus	1	1.8
genus undetermined	1	1.8
TOTAL	55	

the smaller yield of specimens is more likely due to less extensive prospecting (about 5,700 man-days having been spent collecting in the Edmonton as opposed to 10,000 in the Oldman), and steeper, less accessible exposures.

The specimen list given here for member B of the Edmonton Formation differs slightly from that appearing in Russell and Chamney (1967). This is because of the exclusion of isolated cranial elements and the inclusion of several fragmentary hadrosaur specimens in the collections of the National Museum of Canada, which, though lacking precise locality information, were in all probability taken from member B.

DINOSAURIAN SPECIMENS COLLECTED FROM THE EDMONTON FORMATION (MEMBER B) ALONG THE RED DEER RIVER, ALBERTA

	Number of specimens	Percentage of fauna
Family ORNITHOMIMIDAE	12	14.0
Family TYRANNOSAURIDAE	4	4.7
Family HYPSILOPHODONTIDAE	1	1.2
Family HADROSAURIDAE	47	54.7
Subfamily HADROSAURINAE (*Edmontosaurus*)	1	1.2
Subfamily SAUROLOPHINAE (*Saurolophus*)	5	5.8
Subfamily LAMBEOSAURINAE (*Hypacrosaurus, Cheneosaurus*)	22	25.6
subfamily undetermined	19	22.1
Family PACHYCEPHALOSAURIDAE	3	3.5
Family NODOSAURIDAE	6	7.0
Subfamily ANKYLOSAURINAE	1	1.2
subfamily undetermined	5	5.8
Family CERATOPSIDAE	13	15.1
Anchiceratops	8	9.3
Arrhinoceratops	1	1.2
genus undetermined	4	4.7
TOTAL	86	

Dinosaurs have been found only in the two lower members of the lower Edmonton Formation, each of which contains a distinctive assemblage of hadrosaurs (see Russell and Chamney 1967). The lowermost unit (member A) is characterized by the presence of coal seams, brackish water deposits in the lower levels, and a dinosaur fauna in its upper 150 feet, which is dominated by the flat-headed hadrosaur *Edmontosaurus*. The succeeding unit (member B), lacking coal seams over its entire thickness of 250 feet,

was deposited under predominantly freshwater conditions and is typified by an association of the lambeosaurine genera *Cheneosaurus* and *Hypacrosaurus*. It seems propable that *Edmontosaurus* preferred coastal swamp environments, while *Cheneosaurus* and *Hypacrosaurus* (and the antecedent *Procheneosaurus*, *Corythosaurus*, and *Lambeosaurus* occurring in the coal-free portions of the Oldman Formation) frequented bodies of fresh water near the sea.

Saurolophine hadrosaurs are abundant neither in the Oldman Formation nor in member B of the Edmonton Formation and are entirely lacking in member A of the Edmonton. However, *Saurolophus* occurs in some abundance in late Cretaceous deposits in the Nemegt Basin in southern Outer Mongolia (Rozhdestvensky 1957, 1960) where it is the only genus of hadrosaur thus far identified. As this portion of Asia was some distance from late Cretaceous strandlines (see, for example, Morris 1936), it may be that the rarity of saurolophines in Alberta is due to their possible preference for more inland or elevated environments.

Skulls of the thick-headed ceratopsian *Pachyrhinosaurus* are known from member A of the Edmonton Formation (Langston 1967) and equivalent strata in southern Alberta (Sternberg 1950*b*). Collections of dinosaurian material in the National Museum of Canada from one of the latter localities (St. Mary River Formation at Scabby Butte) are currently being described by Langston.

DEPOSITS OF LANCIAN AGE

The youngest dinosaur assemblages in Canada have been collected from sediments exposed along the Red Deer River in Alberta (upper Edmonton Formation) and in southwestern Saskatchewan (Frenchman Formation). These sediments were deposited after an interlude of marine deposition (Battle Formation and equivalents), which in central Alberta separates them from the underlying continental lower Edmonton sequence (see Russell and Chamney 1967). The large, horned dinosaur *Triceratops* is abundant in these and correlative sediments throughout the western interior of North America, where it has been considered a guide fossil for Lancian age deposits. The *Triceratops* faunas existed up to the time of the great extinctions marking the Mesozoic-Cenozoic boundary (Jeletzky 1960, 1962).

Lancian sediments in Canada have not as yet been adequately sampled, and in southwestern Saskatchewan specimens have come from widely scattered localities. However, peculiarities of the faunas as presently known do suggest the existence of some regional variation in faunal composition. For example, *Leptoceratops* has not been identified in any Lancian deposits in Canada or the United States except in those of the upper Edmonton

Formation in Alberta, where it seems to be rather abundant. Articulated remains of hadrosaurs are unknown from this locality, although some scraps of hadrosaur bone have been seen in the field (Sternberg 1949: 33). *Triceratops*, though moderately abundant, is less common here than in other localities of Lancian age sediments.

Triceratops is very abundant in the Frenchman Formation, about 275 miles southeast of the area of outcrop of the upper Edmonton. At least one articulated skeleton of the flat-headed hadrosaur *Anatosaurus* is known. An undescribed frill of a large, long-squamosalled ceratopsian with fenestrated parietals and squamosals, collected from the Frenchman Formation, is preserved in the collections of the Eastend Museum, Saskatchewan (pers. comm. L. S. Russell, C. M. Sternberg 1966). Fragmentary remains of ornithomimids and tyrannosaurids are also known from this unit (Sternberg 1924).

The principal localities of the Hell Creek Formation, lying in east-central Montana, about 200 miles southeast of the exposures of the Frenchman Formation, have produced a large dinosaurian assemblage in which *Triceratops* is extremely abundant (Brown 1907, 1917, 1933; Erickson 1966); *Anatosaurus* is comparatively rare (see specimen lists in Lull and Wright 1942: 21-22). *Anatosaurus* appears to have been more frequently encountered in the exposures of the Lance Formation in central eastern Wyoming, about 330 miles south-southeast of those of the Hell Creek beds, where about half as many specimens have been collected as of *Triceratops* (compare specimen lists in Lull 1933: 15, and Lull and Wright 1942: 23).

DINOSAURIAN SPECIMENS COLLECTED FROM THE UPPER EDMONTON FORMATION ALONG THE RED DEER RIVER, ALBERTA

	Number of specimens	Percentage of fauna
Family ORNITHOMIMIDAE	1(?)	5.6
Family TYRANNOSAURIDAE	2	11.1
Family HYPSILOPHODONTIDAE	1	5.6
Family NODOSAURIDAE (Subfamily ANKYLOSAURINAE)	2	11.1
Family PROTOCERATOPSIDAE (*Leptoceratops*)	6	33.3
Family CERATOPSIDAE (*Triceratops*, including 2 specimens not collected)	6	33.3
TOTAL	16	

DINOSAURIAN SPECIMENS COLLECTED FROM THE FRENCHMAN FORMATION, SOUTHWESTERN SASKATCHEWAN

	Number of specimens	Percentage of fauna
Family COELURIDAE	1?	5.25
Family HYPSILOPHODONTIDAE	1	5.25
Family HADROSAURIDAE *(Anatosaurus)*	2	10.50
Family CERATOPSIDAE	15	79.00
Triceratops (including 2 specimens not collected)	14	73.75
undetermined long-squamosalled ceratopsian	1	5.25
TOTAL	17	

Thus *Anatosaurus* seems to become increasingly abundant in a southeasterly direction from Lancian sediments on the Red Deer River in Alberta. *Triceratops*, which is everywhere abundant, is especially so in Lancian sediments between southern Alberta and eastern Wyoming. If these distribution patterns are accurate, they may be consistent with a hypothetical topographic gradation from an interior piedmont plains environment with abundant protoceratopsids in the northwest to low floodplains bordering the remnant of the midcontinental seaway in the southeast.

Occupying the position in time that they do, the Lancian faunas have been studied for possible antecedent influences of the great extinctions that destroyed them and brought the dinosaurian era to a close. The outstanding characteristic of the faunas is the great abundance of a single genus of dinosaurs (*Triceratops*), a situation that is unprecedented in earlier late Cretaceous faunas. Lambeosaurine and saurolophine hadrosaurs as well as panoplosaurine nodosaurs have not thus far been described from Lancian sediments in the interior of North America. However, the ubiquitous abundance of *Triceratops* bespeaks a rather limited range of environmental conditions over much of this area. Saurolophine hadrosaurs are known from possibly correlative strata in California (Moreno Formation, pers. comm. Van Couvering 1966), and the other missing forms may be found elsewhere in latest Cretaceous deposits in North America. Colbert (1965: 197-203) has suggested that the absence of certain dinosaurian groups in Lancian strata may signal the beginning of the general extinctions marking the close of Cretaceous time. Although this may prove to be the case, it may be useful to keep in mind the possibility that the peculiarities of the Lancian fauna could be the result of the immigration of new forms and/or the onset of slightly different environmental conditions unrelated to the ultimate demise of the dinosaurs.

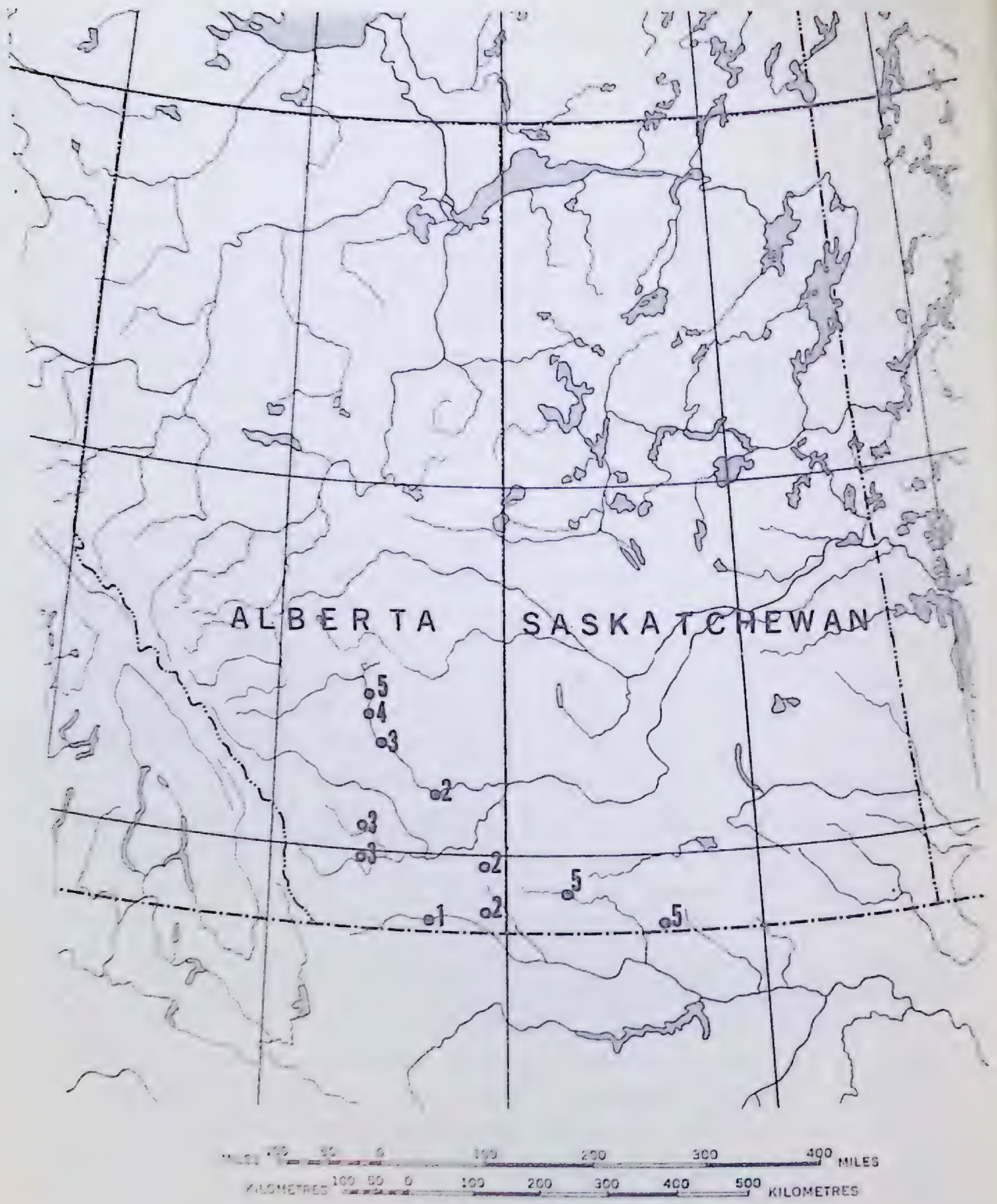

FIGURE 1. Dinosaur localities in western Canada. The small circles which are situated approximately in the centre of the fossiliferous exposures do not necessarily contain all of the exposures at a particular locality. Numbers identify localities at the following horizons: 1 – Milk River Formation; 2 – Oldman Formation; 3 – Edmonton Formation (member A and equivalents); 4 – Edmonton Formation (member B); 5 – Strata of Lancian age.

SUMMARY

A census has been made of dinosaurian specimens collected from the historically more important localities in late Cretaceous sediments of western Canada. Specimen lists based on this census are presented, with qualifications, to promote a clearer understanding of the composition of the various dinosaurian assemblages.

Parasaurolophus and *Styracosaurus*, which have been considered typical Oldman ('Belly River') forms, are actually rare in the deposits along the Red Deer River, and *Monoclonius* (*s. str.*) is recorded from this locality for the first time. Stratigraphic and palaeogeographic evidence suggests that the lower Edmonton hadrosaurs, *Edmontosaurus*, *Cheneosaurus* and *Hypacrosaurus*, and *Saurolophus* may have respectively preferred marginal brackish water swamps, bodies of fresh water near the sea, and inland or elevated freshwater bodies.

Dinosaur faunas of Lancian age are dominated by a single genus, *Triceratops*, although *Anatosaurus* shows a tendancy to increase in relative abundance from Alberta to eastern Wyoming. In general, however, Lancian faunas seem to be of rather uniform composition over much of the interior of North America, with some provincialism in central Alberta. Evidence is as yet insufficient to demonstrate a general reduction in the diversity of dinosaurs prior to their extinction at the close of Lancian time.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

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Department of the Secretary of State

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FOUR NEW SUBSPECIES OF LEIOCEPHALUS STICTIGASTER FROM CUBA

by ALBERT SCHWARTZ* and ORLANDO H. GARRIDO**

ABSTRACT

Se describen cuatro subespecies nuevas de *Leiocephalus stictigaster* Schwartz, lagartija endémica de Cuba y de la Isla de Pinos: *L. s. naranjoi* (localidad típica: Los Biasmones, Casilda, Provincia de Las Villas), *L. s. lipomator* (localidad típica: 3 km al oeste de Santa Clara, Provincia de Las Villas), *L. s. celeustes* (localidad típica: Contramaestre, Provincia de Oriente), y *L. s. gibarensis* (localidad típica: Gibara, Provincia de Oriente). La primera se encuentra en la zona Casilda-Trinidad y en Juraguá al oeste de la Bahía de Cienfuegos; la tercera se encuentra en los alrededores de Bayamo, Bueycito, y Contramaestre. Las conocidas distribuciones de *L. s. lipomator* y *L. s. gibarensis* están restringidas a las localidades típicas. Hay otra población de Oriente que aun se encuentra sin nombre: un ejemplar de La Gran Piedra representa casi sin duda alguna una subespecie que requiere ser nombrada más tarde.

Dos especies cubanas de *Leiocephalus, stictigaster* y *cubensis,* no habían sido encontradas anteriormente en el mismo lugar; se suponía que eran alopátricas. En el Río Guaurabo, vecinidad de Trinidad, fué descubierta *L. stictigaster* entre los límites de su zona ecológica de preferencia normal de *L. cubensis.* Otros sitios de contacto entre ambas especies son la zona de Juraguá-Cinco Tiras (pero no se sabe si sean simpátricas o separadas ecologicamente) y en la localidad típica de *L. s. lipomator,* donde *L. cubensis* se cogió junta a la más abundante *L. stictigaster.*

Leiocephalus stictigaster Schwartz is the most recently described Cuban species of its genus. Four subspecies of *L. stictigaster* were named at the time of the description of the species (Schwartz 1959); of these four races, two *(stictigaster, sierrae)* occur in western Cuba in Pinar del Rĩo Province and two *(exotheotus, astictus)* on the Isla de Pinos. Later, three eastern subspecies were named (Schwartz 1960 and 1964): *lucianus* and *ophiplacodes* from Camagüey Province and *parasphex* from Cayo Sabinal off the northern Camagüey coast. In the latter paper, the senior author (Schwartz 1964:221-22) commented that it seemed reasonable to expect

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that the distribution of *L. stictigaster* was not so disjunct as the five mainland Cuban subspecies indicated and that other populations remained to be discovered between Pinar del Río Province in the west and Camagüey Province in the east. Reference also was twice made (Schwartz 1959:110, and 1964:221) to three specimens with *L. stictigaster* affinities from the Bayamo area in Oriente Province. These three lizards were very distinctive when compared with all other samples, but the facts that they had not been brought together for study and that the sample was very small were distinct deterrents to according nomenclatural recognition to the Oriente form.

Through the efforts of the junior author, a long series of *L. stictigaster* has been accumulated from the southern portion of Las Villas Province. These lizards are geographically intermediate between the western Pinar del Río and the eastern Camagüey lizards. Therefore, the suggestion by Schwartz that there are other populations of *L. stictigaster* closing the hiatus between the two more remote areas occupied by the species has been verified. Secondly, not only have the original three Bayamo specimens been brought together, but an additional very long series of this Oriente population was discovered by the junior author in the collection of the Universidad de la Habana. Garrido, accompanied by Miguel L. Jaume of the Museo Felipe Poey, secured still more material from the Bayamo region in 1967. Consequently, there is now ample material for the study of this eastern subspecies, which proves to be quite distinct from all others. Thirdly, another Oriente population has been discovered by the junior author at Gibara, on the north-central Oriente coast; the Gibara lizards, although allied to *L. s. lucianus* to the west, are also distinctive. Finally, Garrido collected a single *L. stictigaster* at an elevation of about 1,000 meters on Gran Piedra in southern Oriente, east of the city of Santiago de Cuba. This lizard also appears to be quite distinctive when compared with the nearest geographical population, and we have little doubt that once more material is secured from the Sierra de la Gran Piedra it too will be worthy of nomenclatural recognition. A short series from the vicinity of the city of Santa Clara in Las Villas Province gives a third locality for *L. stictigaster* in central Cuba. It is obvious that there is still much to be learned about the distribution and variation of *L. stictigaster* throughout Cuba.

We have examined material from the following Cuban collections and extend our most sincere thanks to the respective curators for the loans of these interesting lizards: Museo Poey (MFP), Miguel Jaume; Museo y Biblioteca de Zoología de la Habana (MBZH), Miguel Jaume; Universidad de la Habana (UH), Darío Guitart and Vitelio Vitier. We have also examined specimens from the private collections of Sr. Jaume (MJ) and Mario S. Buide (MSB), to whom we are grateful. The long series of *L. stictigaster* from Los Biasmones in Las Villas Province was collected by Telmo Naranjo Casadevall, who was the original discoverer of this population. Specimens collected by Sr. Naranjo and the junior author are in the Instituto de Biología, Academia de Ciencias (IB). Expeditions upon which *L. stictigaster* were collected by the junior author were financed by the Instituto de Biología; able assistance on these expeditions was rendered by Jorge de la Cruz, Telmo Naranjo and Ponciano Bravo who merit our gratitude. An expedition in 1967, jointly sponsored by the Instituto de Biología and the Museo Felipe Poey, was made by the junior author

in the company of Miguel L. Jaume, George C. Gorman, René Pérez and Luis Méndez; on this particular trip the status of the Gibara population was clarified and the series from Santa Clara was secured. Finally, we wish to extend our thanks to Dra. Teresita del Valle and Dra. Aurelia Longoria who made it possible for the junior author to examine material in the collection of the Universidad de la Habana. Paratypes of the new subspecies have been designated in some of the above collections and have been deposited in the Albert Schwartz Field Series (ASFS), the Museum of Comparative Zoology (MCZ), and the National Museum of Canada (NMC). We are in the debt of Ing. Héctor Sagué D. and George C. Gorman without whose cooperation the present study could not have been undertaken.

We wish to thank also David C. Leber for the execution of the illustrations of the throat patterns, and Charles M. Bogert and George W. Foley for facilitating the loan of the holotypes of several subspecies in the American Museum of Natural History (AMNH).

We take great pleasure, in honor of Telmo Naranjo Casadevall, in naming the southern Las Villas population of *L. stictigaster* as

Leiocephalus stictigaster naranjoi, new subspecies

Holotype. IB 200, an adult male, from Los Biasmones, Casilda, Las Villas Province, Cuba, one of a series collected in March 1965 by Telmo Naranjo Casadevall.

Paratypes. IB 201, same data as holotype; IB 202-04, IB 226, IB 247-50, same locality and collector as holotype, 20 January 1966; IB 220-25, IB 227-29, IB 231-33, IB 237, IB 251, same locality as holotype, 6 March 1966, O. H. Garrido; ASFS VIII92-96, Playa de Marĩa Aguilar, Casilda, Las Villas Province, Cuba, 1965, T. Naranjo; IB 238, IB 240, Playa de Marĩa Aguilar, Casilda, Las Villas Province, Cuba, 6 March 1966, O. H. Garrido; MCZ 92031-35, NMC 9644-53, Playa de Marĩa Aguilar, Casilda, Las Villas Province, Cuba, 15 March 1965, O. H. Garrido; ASFS VIII97-202, IB 216, Cayaguazán, Casilda, Las Villas Province, Cuba, 7 March 1966, O. H. Garrido; IB 253, Ceiba de Hernán Cortés, Rĩo Guaurabo, Trinidad, Las Villas Province, Cuba, 6 March 1966, O. H. Garrido; IB 954-55, Casilda, Las Villas Province, Cuba, 1 September 1966, T. Naranjo Casa de vall.

Associated Specimens. Cuba, Las Villas Province, Juraguá, 35 (MSB 524-27, ASFS VIII83-91, ASFS VII203-06, IB 418-29, MCZ 92026-30); 3 km from Juraguá (IB 407).

Definition. A subspecies of *L. stictigaster* characterized by a lined dorsum with no brown or black markings in any zone, Zone 5 (lateral band) reddish brown with a profusion of clear green dots, Zones 4 and 6 narrow and clear whitish to tan, throat in males with a fragmented pattern of dark brown lines on a gray ground, venter immaculate, postocular spot blackish, and parietal scales usually not in contact.

Distribution. Known from southern Las Villas Province, Cuba, in the vicinities of Juraguá to the west of the Bahĩa de Cienfuegos, and Casilda near the city of Trinidad (Figure 1).

Description of holotype. An adult male with the following measurements (in millimeters) and counts: snout-vent length 87, tail (broken) about 145, snout to anterior border of tympanic opening 18.8, head width 15.0, supraocular scales 5/6, loreals 5, temporals 13, enlarged auricular scales 4/4, median head scales 5, prefrontal row complete, 3 scales, frontoparietal row complete, 5 scales, supraorbital semicircles complete, parietal scales not in contact, dorsal crest scales occiput to vent 54, dorsal crest scales occiput to axilla 22, scales around one half body at midbody 25, fourth toe subdigital tricarinate scales 23/24.

The dorsal coloration of the holotype is generally chocolate brown, with the lateral bands (Zone 5) well marked with dots of terra-cotta or reddish, and green. The coloration and pattern of the various zones (we follow the usage of Schwartz, 1959:98, in designation of zones) are as follow. Zone 1: dark brown, occupying

PLATE I

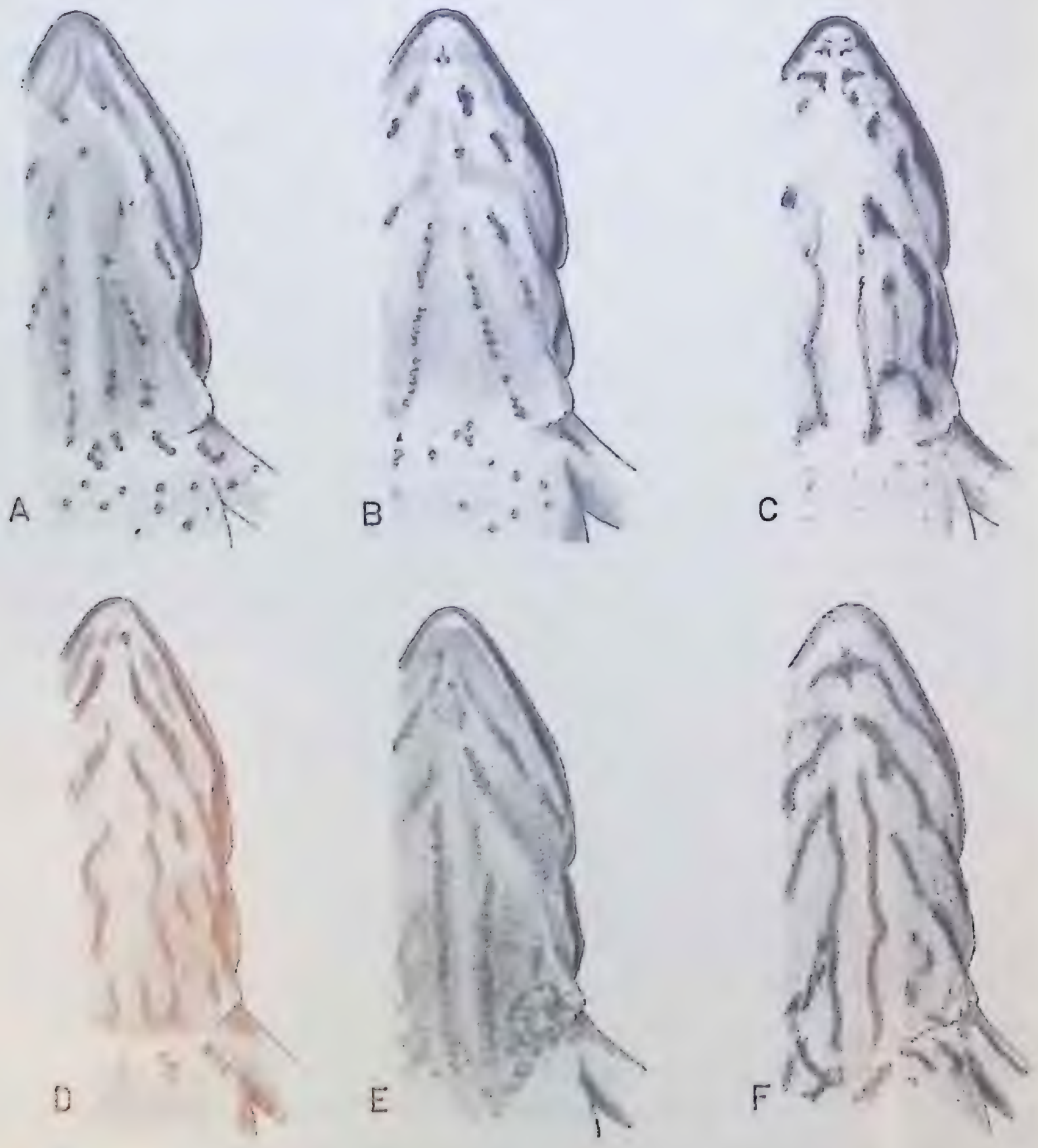

PLATE I (Cont'd)

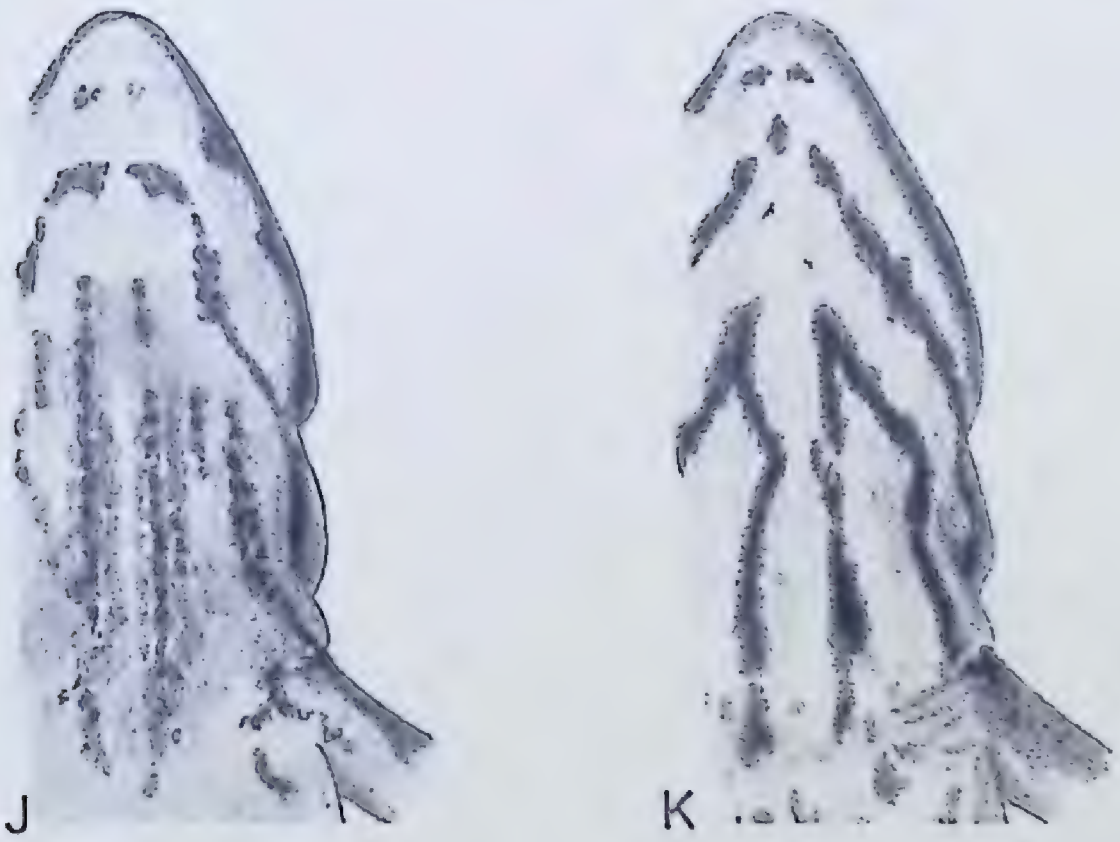

Plate I

Throat patterns of eleven subspecies of *L. stictigaster;* in each case the holotype is illustrated. A, *L. s. stictigaster* (AMNH 77864); B, *L. s. sierrae* (AMNH 77813); C, *L. s. exotheotus* (AMNH 81088); D, *L. s. astictus,* (AMNH 81095); E, *L. s. naranjoi* (IB 200); F, *L. s. lipomator* (IB 1230); G, *L. s. ophiplacodes* (AMNH 92771); H, *L. s. parasphex* (AMNH 92153); I, *L. s. lucianus* (AMNH 83583); J, *L. s. celeustes* (IB 1182); K, *L. s. gibarensis* (IB 1236).

both sides of the dorsal crest scales; this zone is darker than Zone 2 and of the same color as Zone 3, has no spots or dots, and is approximately the same width as Zone 2; Zone 2: of the same width as Zone 1 but brighter, i.e., a grayer brown; Zone 3: practically double the width of Zone 2 and encompassing about four rows of scales; color brown, comparable to that of Zone 1 and without spots or dots; Zone 4: a narrow longitudinal line, one and one half to two scales in width, whitish

TABLE 1. Meristic data on eleven subspecies of *L. stictigaster*. NUMBER OF specimens included within parentheses after subspecific name.

	stictigaster (53)	*sierrae* (63)	*exotheotus* (35)	*astictus* (25)	*naranjoi* (92)	*lipomator* (6)	*lucianus* (48)	*gibarensis* (25)	*parasphex* (21)	*ophiplacodes* (13)	*celeustes* (62)
Largest ♂	79	81	77*	79	87	68	78	84	75	73	100
(mm) ♀	72	67	61*	62	68	58	58	71	59	70	80
Parietal contact +	59	78	47	27	26	0	73	91	22	58	46
(%) −	41	22	53	73	74	100	27	9	78	42	54
Semicircles +	40	66	55	86	85	75	72	12	80	58	86
(%) −	60	34	45	14	15	25	28	88	20	42	14
Dorsal crest scales											
occiput-vent	54.2 (48-62)	49.9 (45-55)	48.7 (43-53)	49.2 (45-54)	53.2 (45-60)	54.0 (50-57)	51.6 (45-56)	50.5 (46-55)	52.1 (46-58)	57.2 (51-60)	53.6 (47-58)
occiput-axilla	22.7 (19-28)	19.3 (16-24)	21.1 (15-26)	21.5 (17-26)	20.7 (17-25)	20.2 (18-22)	22.0 (18-29)	19.5 (15-24)	19.5 (16-22)	22.1 (18-27)	20.4 (16-26)
One-half midbody	24.8 (22-28)	24.9 (21-32)	23.3 (19-26)	22.0 (20-25)	20.7 (17-25)	25.0 (23-27)	23.8 (21-27)	22.5 (20-25)	22.9 (21-27)	27.2 (25-30)	22.0 (20-26)
Loreals	4.8 (3-8)	4.8 (3-10)	4.5 (2-7)	5.0 (3-7)	5.2 (3-9)	7.3 (5-10)	4.9 (3-8)	5.0 (3-7)	5.2 (3-10)	5.6 (4.8)	4.5 (2-8)
Temporals	12.7 (10-16)	12.5 (10-16)	11.4 ((8-15)	11.0 (9-12)	12.0 (10-15)	12.7 (12-14)	11.4 (9-14)	11.3 (9-14)	11.4 (10-14)	13.1 (11-15)	12.2 (10-15)
Fourth toe	23.4 (20-27)	23.8 (21-28)	22.2 (19-27)	22.8 (20-25)	23.9 (20-28)	24.5 (22-27)	24.3 (21-27)	23.0 (21-27)	23.6 (22-26)	24.1 (18-28)	23.2 (20-26)
Frontoparietal row (mode)	5	5	5	5	5	5	5	5	5	7	5
Ventral dotting (+ = present, − = absent)	+	+	+ (or −)	−	−	+	+	+	−	−	+ (or −)

*indicates new upper size limits in both sexes of *exotheotus*, above those given by Schwartz (1959) based on more recently collected material.

in color (brighter anteriorly and centrally), extending from above the posterior portion of the eye as far as slightly posterior to the hindlimb insertions; Zone 5: narrow, occupying five or six rows of scales; this zone is basically reddish terra-cotta in in color, the color due to the two pigments (red and terra-cotta) which occur in the form of dots, especially medially between the fore- and hindlimbs; some greenish flecks also occur in Zone 5 from behind the postocular patch to the hindlimb insertions; Zone 6: a white longitudinal line, the same width as Zone 4 (although paler and brighter than Zone 4) from below the ear opening to the insertion of the hindlimbs. Below these zones is a less well defined area (Zone 7) with terra-cotta, blackish, and greenish pigments. The green and terra-cotta dots are less numerous as this pigmented area approaches the immaculate venter, which is white to whitish gray laterally and yellowish centrally.

The throat is greenish gray, this color extending as far posterior as the chest. The throat pattern consists of two grossly fragmented dark gray V's, their apices pointed anteriorly, of which the more anterior is the more complete. A pair of paramedian gray lines extends onto the chest; the chest itself is dotted with fine gray to brownish dots (Plate I E). The limbs are brown above and show some remnants of brown and terra-cotta dotting. The color of the upper surface of the tail is similar to that of the limbs, and the sides of the tail are marked with terra-cotta dots. The groin and region about the vent are immaculate yellow, but the remainder of the underside of the tail is dotted with brown and terra-cotta.

The upper surface of the head is immaculate brown, brighter than that of Zones 1 and 3. The postocular spot is blackish and well defined, contrasting with the brighter color of Zone 5 in which it lies. The supra- and infralabials are blackish or dark brown, somewhat brighter than the postocular spot.

Variation. The paratypic series plus the associated specimens total 91 lizards. The largest male is the holotype; the largest female (IB 214) has a snout-vent length of 68 mm. Dorsal crest scales in occiput-vent length (combined data for both sexes) average 53.2 (45 - 60) and dorsal crest scales in occiput-axilla length average 20.7 (17 - 25). One half scales at midbody average 23.5 (20 - 27), loreals 5.2 (3 - 9), temporals 12.0 (10 - 15), subdigital tricarinate scales on the fourth toe 23.9 (20 - 28). The parietals are more often (74 percent) not in contact, the supraorbital semicircles more often (85 percent) complete than not. The prefrontal row is regularly composed of 3 scales and more often complete (79 of 89 lizards); median head scales vary from 4 to 8, with a mode of 4 (41 lizards, with 5 medians having the next highest incidence, 21 lizards); the frontoparietal row is composed of from 3 to 6 scales, with a mode of 5 (67 lizards) and is more often complete (84 of 86 lizards). Table 1 shows meristic data for all subspecies.

The holotype and paratypes are from the region about Casilda, whereas the associated specimens are from Juraguá, some 70 kilometers airline to the northwest and on the western side of the deeply indented Bahĭa de Cienfuegos. The color and pattern of the two lots will be discussed separately.

The topotypic series is composed of 35 males and 21 females. Males agree with the description of the holotype in dorsal color and pattern. The throat pattern

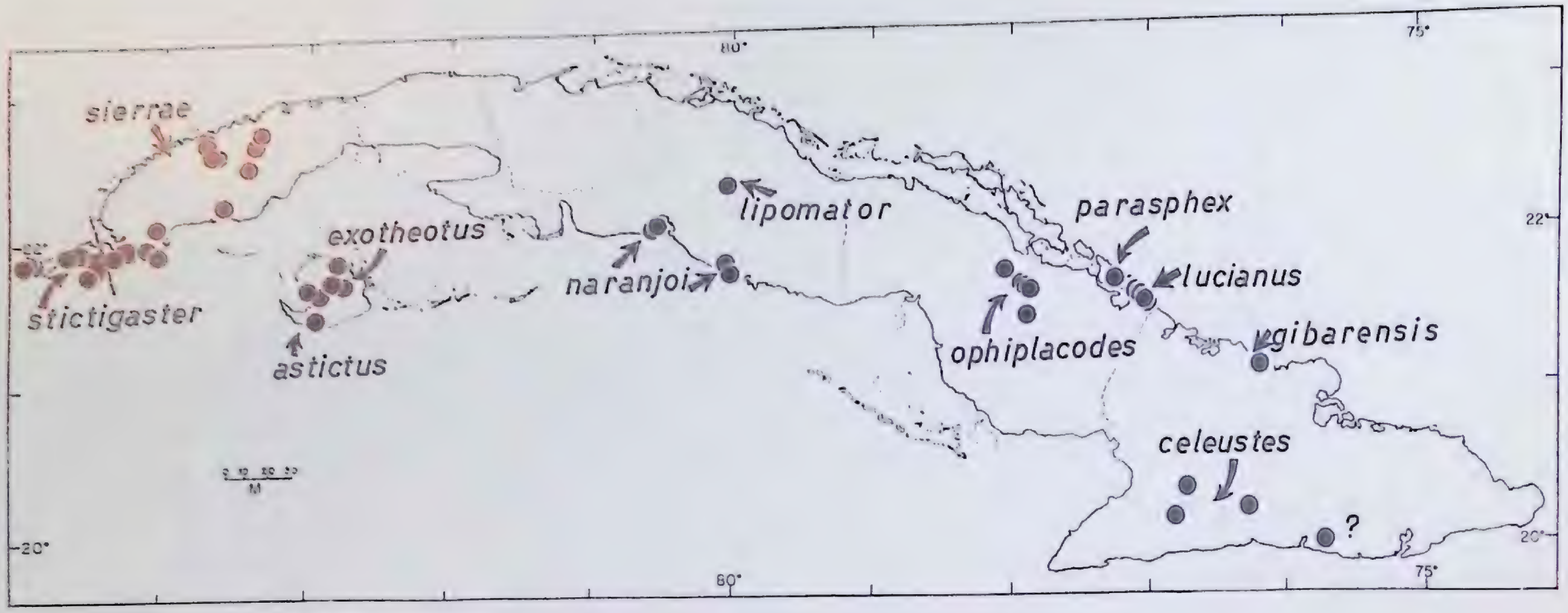

Fig.

1 Map of Cuba and Isla de Pinos, showing distribution of the subspecies of *Leiocephalus stictigaster*. Boundary between the ranges of *L. s. stictigaster* and *L. s. sierrae* indicated by dashed line. Questioned symbol in Oriente Province shows locality whence the species is known but where subspecific assignment of the population is uncertain. Some localities have been omitted for clarity and some symbols represent specimens from unpublished localities.

is somewhat variable but consists regularly of a pair of V's and a pair of more posterior paramedian lines. The condition in the type (lines gray and fragmented) is paralleled in many of the topotypic males, but other males have the lines more entire and darker in color. Such differences are not due to ontogenetic change since young and adult males have the throat pattern in either condition. The chest may be fairly coarsely to lightly dotted or spotted with brownish to gray, but the dotting or spotting does not continue onto the venter. The paramedian throat lines at times are fused with the more posterior of the two throat V's, and there may be an additional more lateral pair of lines on the posterior throat and chest, resulting from fusion of some of the chest dots and spots. There is rarely a dark dot near the chin before the apex of the more anterior V.

The color of the male topotypes and near topotypes varies slightly with locality. In males from Playa de Marĭa Aguilar, Zones 1 and 3 are of a brighter brown than in males from Los Biasmones, whereas males from Cayaguazán have the brown darker and more intense. Specimens from Marĭa Aguilar have less green dotting in Zone 5. Zones 4 and 6 in males from Marĭa Aguilar and Los Biasmones are similar although somewhat brighter in the Marĭa Aguilar lizards. In the series from Cayaguazán, Zone 4 is creamy and clear, and Zone 6 is whitish and less clearly defined. Heads are always brown and without markings. The venter is yellowish centrally in all males and grayish white peripherally; some males have some lateral terra-cotta dotting on the sides of the abdomen, but these dots are completely absent in 95 percent of the males.

Female topotypes and near topotypes are much like the males dorsally. In some females from Playa de Marĭa Aguilar there are brown spots or figures in Zone 3, but these markings are less obvious in females from Los Biasmones and Cayaguazán. In general, the dorsal female pattern shows the zones better delineated than does that of the males. Terra-cotta and green dots are less discernible in females than in males. The female throat pattern is like that of males and shows the same variation in intensity and completion. There is a tendency for the chests of females to be more suffused with gray than those of males. Juvenile males are much like females in color and pattern, including the presence of some brown markings in Zone 3.

The series of *L. s. naranjoi* from Juraguá is composed of 25 males and 11 females. In dorsal color and pattern, these lizards are quite close to specimens from the Casilda area except that they were darker in life. One feature is rather different: in Juraguá males the postocular patch is less bold and well separated in color from Zone 5. The throat pattern in males is like that of topotypical *naranjoi* except that it carries the narrowing and fragmentation of the lines even further. Almost all males have the throat pattern broken and disjunct, and in some specimens (MSB 524) the pattern is reduced to a series of widely separated dark brown to black dots in the position of the normal throat lines. The throat pattern of females from both populations is similar, but there is a distinct tendency for Juraguá females to have the throat ground color much more suffused with dark gray than in Casilda females. It is possible, considering the geographic separation of these two samples, that they represent two subspecies rather than one, but the present series does not so indicate and we group them together as *L. s. naranjoi.*

Comparisons. Only three described subspecies of *L. stictigaster* have green pigment in the lateral bands – *naranjoi, exotheotus,* and *astictus.* From *exotheotus, naranjoi* differs in having the pale longitudinal lines (Zones 4 and 6) white rather than yellow and in having the venter immaculate rather than usually dotted with brown (although this is a variable feature in male *exotheotus*). The throat patterns of the two races are very distinct (Plate I C and E), since *exotheotus* lacks the two inverted V's and has the pair of paramedian dark lines indistinct. From *L. s. astictus, naranjoi* differs primarily in having Zone 4 and 6 much narrower. The green lateral scales in *astictus* are more scattered and of a darker green than those of *naranjoi* in which subspecies these scales are more numerous and paler. Both taxa have comparable throat patterns, although the pattern of *naranjoi* males is better defined and more complete than that of *astictus* males. From both *exotheotus* and *astictus, naranjoi* differs in having a postocular spot; the two Isla de Pinos subspecies lack this feature.

Comparisons with the Pinar del Rĭo and Camagüey subspecies are hardly necessary. Both nominate *stictigaster* and *sierrae* have the venters heavily dotted with brown and have dark dashes in Zones 3 and 5 – features which *naranjoi* lacks. Zones 4 and 6 are much broader in *stictigaster* than in *naranjoi.* In *sierrae* (which resembles *naranjoi* in dorsal hues), there are no green scales; on the other hand *sierrae* has orange in Zone 5 which *naranjoi* lacks in the lateral bands.

From the Camagüey subspecies *(parasphex, lucianus, ophiplacodes), naranjoi* differs in lacking the orange pigments which occur in Zones 3 and 5 of *parasphex* and *ophiplacodes.* Zone 4 in *parasphex* is wider and darker (tan) than in *naranjoi.* The throat patterns of the three Camagüey subspecies Plate IG, H, I) likewise differ in detail from that of *naranjoi.* In *parasphex,* the throat is reticulate; in *ophiplacodes,* the pattern is grossly incomplete. The throat pattern of male *naranjoi* resembles most closely that of male *lucianus,* in that both have a pair of inverted V's and a paramedian pair of posterior throat lines. In *lucianus* there is a pre-V spot or bar near the chin (a feature which occurs very rarely in *naranjoi*), and the throat lines are much broader and darker than in *naranjoi.* Zones 3 (regularly) and 5 (occasionally) in *lucianus* have dark dots and marks which do not occur in *naranjoi,* and *lucianus* lacks a clearly evident postocular spot. The two races differ in other pattern and pigmental details as well.

In size, *L. s. naranjoi* is larger than any previously described subspecies; maximally sized male *naranjoi* have a snout-vent length of 87 mm, whereas the largest males of other races are smaller, with *sierrae* (81 mm) approaching *naranjoi* most closely in size. Female *naranjoi* likewise are larger than females of the other subspecies, although they too are almost equalled by female *sierrae* (67 mm). In having the parietals more often not in contact, *naranjoi* is like *exotheotus, astictus,* and *parasphex,* and unlike *stictigaster, sierrae, lucianus* and *ophiplacodes* which modally have the parietals more often in contact. In having the supraorbital semicircles usually complete, *naranjoi* is like all subspecies except *stictigaster* which alone has the semicircles more often incomplete. In scale counts, and numbers and relationships of the head scales, *naranjoi* does not differ strikingly from the balance of the subspecies.

Remarks. In the area of the type locality, *L. s. naranjoi* occupies coastal or near-coastal areas. In the coastal regions (Punta de Casilda, Playa de María Aguilar) *naranjoi* inhabits a vegetational cover of scattered creeping plants on sandy soils and rocks. In the region of Los Biasmones (which lies near Casilda and back from the coast), the lizards occur on dry clayey soils which are little cultivated except for some fruit trees. The Los Biasmones lizards live in close association with man, occupying roadsides where they take refuge in fence rows and other chinks and crannies. At Los Biasmones the lizards occur also in neighboring fields and pastures where the vegetation is low grass; however, they are less abundant in such habitats.

At Cayaguazán, further back from the coast, the area is fertile and cultivated, and there is a moderately large lake. The lizards were encountered from the lake shore to adjacent pastures. Along the Río Guaurabo the vegetational cover is quite different and much more mesic. At this locality, *L. cubensis* was the dominant *Leiocephalus.*

The series from Juraguá was secured from among rocks along the roadside and among sisal plants.

The recent collection of a short series of *L. stictigaster* from the vicinity of the city of Santa Clara, Las Villas Province, demonstrates the occurrence of another population of this species in central Cuba. In allusion to their isolated position, these lizards, from the Greek word for "orphan," may be called

Leiocephalus stictigaster lipomator, new subspecies

Holotype. IB 1230, an adult male, from 3 kilometres west of Santa Clara, Las Villas Province, Cuba, one of a series collected 12 March 1967 by Orlando H. Garrido and Miguel L. Jaume.

Paratypes. ASFS VII753-54, IB 1231, MFP – 2 specimens, same data as holotype.

Definition. A subspecies of *L. stictigaster* characterized by a combination of grayish brown and strongly lineate dorsum with black markings in Zone 3, Zone 5 (lateral band) brownish terra-cotta with scattered pale green dots, Zones 4 and 6 narrow and whitish to cream; throat in males with a pattern consisting of a complete pair of black V's with their apices directed anteriorly and a pair of black paramedian lines, venter dotted with brown dots, postocular spot absent or represented only by its own brown margin, high number of loreals, and parietal scales not known to be in contact.

Distribution. Known only from the type locality (Plate I A).

Description of holotype. A subadult (or adult?) male with the following measurements (in millimeters) and counts: snout-vent length 62, tail 110, snout to anterior border of tympanic opening 15.2, head width 11.8, supraocular scales 6/5, loreals 6, temporals 14, enlarged auricular scales 4/4, median head scales 4, prefrontal row complete, 3 scales, frontoparietal row complete, 5 scales, supraorbital semicircles complete, parietal scales not in contact, dorsal crest scales occiput to vent 55, dorsal crest scales occiput to axilla 20, scales around one half body at midbody 23, fourth toe subdigital tricarinate scales 23/-.

The dorsal coloration of the holotype is grayish brown and Zone 5 (lateral band) is brownish terra-cotta with scattered pale green dots. The coloration and pattern of the various zones are as follow. Zone 1 and Zone 2 are concolor and grayish brown; Zone 3 equal in width of that of Zone 2, but browner with well marked black markings, arranged as a series of weakly opened U's, extending from above the forearm insertions onto the tail where they gradually become the dark caudal chevrons; Zone 4: a narrow white to cream line, one and a half to two scales in width, from behind the auricular opening to the groin; Zone 5: basically brownish terra-cotta with scattered pale green scales, the green pigment brighter toward the groin; Zone 6: a whitish longitudinal line from the auricular opening to the groin, not prominent and much grayer on the sides of the head as the supralabial stripe; Zone 7: the lower sides are orange-brown with a profusion of green dots. In Zones 1 and 2, there are some whitish dots above the hindlimb insertions and these dots continue onto the sides of the tail. The top of the head is brown and without darker dots or spots, in contrast to the paler grayish brown color of the dorsum. The postocular spot is weakly expressed and represented only by its own darker brown margins. The throat pattern is black on a grayish white ground and consists of a pair of V's, their apices directed anteriorly and a pair of paramedian lines which extend toward the chest and are followed by a pectoral area of coarse black blotches. The paramedian lines join the more posterior of the two gular V's, but the latter is broken in the space between the two paramedians. Anterior to the more anterior V, there is an incomplete third V, which is represented by an almost complete line from about the midline of the chin laterally along the sublabials on the left side and by a similar but less complete line on the right (Plate I F). The venter is uniform whitish with scattered brownish dots, more concentrated anteriorly near the chest. The limbs are brown above and without bright or dark dotting. The tail is chevronate brown and tan throughout its length dorsally and laterally, but is whitish ventrally.

Variation. Other than the holotype, there are five specimens of *L.s. lipomator:* one is a male with a snout-vent length of 68 mm and four are females with snout-vent lengths varying between 50 mm and 58 mm. Dorsal crest scales in occiput-vent length (combined data for all specimens) average 54.0 (50-57) and dorsal crest scales in occiput-axilla length average 20.2 (18-22). One half midbody scales average 25.0 (23-27), loreals 7.3 (5-10), subdigital tricarinate scales on the fourth toe 24.5 (22-27). The parietals are not in contact (100 percent), the supraorbital semicircles are more often (75 percent) complete than not. The prefrontal row is regularly composed of 3 scales and is always complete; median head scales vary between 4 and 6 (modes 4 and 6); the frontoparietal row is composed of 4 or 5 scales, with a mode of 5, and is more often complete (five of six lizards).

The single male paratype agrees with the description of dorsal color and pattern of the holotypic male. This male paratype differs, however, in throat pattern details. As in the holotype, the black throat pattern is composed of two V's and a pair of paramedian lines, and there is even an indication of a third more anterior throat V; but all throat lines in the paratype are broad and coarse and end abruptly on the chest without an area of coarse black blotches or spots as in the holotype. There is, on the chest, a peculiar more or less circular black figure which presumably

has been formed by the coalescence of some black chest spots. The venter in the male paratype is even more heavily dotted with brown than is that of the holotype.

The four female *L.s. lipomator* resemble the males in dorsal color but Zone 3 is even more heavily marked with black spots and in the smallest female (snout-vent length 50 mm) Zone 3 appears to be almost solid black. Zone 5 is brown without green dots, nor does Zone 7 have the orangish terra-cotta hue of males. The venter is heavily flecked with brownish dots, primarily along its sides and near the chest. The throat pattern in females is identical to that of males—two V's, the second incomplete where it joins the paramedian lines and at times somewhat fragmented but still maintaining its integrity, a pair of paramedian lines which end in an area of coarse spots; however, rather than black, the lines are blackish brown in females.

Comparison. L.s. lipomator appears to be closest to *L.s. naranjoi,* both geographically and in characters. Of the described subspecies of *L. stictigaster,* only *naranjoi, exotheotus* and *astictus*—along with *lipomator*—have green scales on the sides. Both *naranjoi* and *astictus* lack ventral dotting in males, whereas *lipomator* and *exotheotus* (usually) have the venters dotted. The throat pattern in *exotheotus* is quite different from that of *lipomator,* since the former lacks so complete an expression of the pattern as occurs in *lipomator.*

From geographically adjacent *naranjoi, lipomator* differs, in addition to having the venter dotted, in being paler (grayish brown in contrast to chocolate brown), in having Zone 3 with black markings, and in lacking a postocular spot (present in *naranjoi*).

L.s. lipomator is remarkable, among all subspecies, in having the highest mean number of loreals (7.3). Other than this high mean, that of *ophiplacodes* (5.6) is the next highest, with the balance of the subspecies having loreal means between 4.5, and 5.2. The few specimens of *lipomator* in contrast to the long series of most other subspecies may well distort the loreal mean, however. In having the parietal scales not in contact, *lipomator* is like all described subspecies except *stictigaster, sierrae, lucianus* and *ophiplacodes;* in having the semicircles more often complete, *lipomator* differs only from nominate *stictigaster.*

Detailed comparison of *L.s. lipomator* with the remaining subspecies (all of which lack green in the lateral fields) is rather simple. The subspecies *stictigaster* and *sierrae* have the venters dotted as does *lipomator* but also have the lateral fields with prominent dark longitudinal dashes—a feature absent in *lipomator.* The throat pattern of *lipomator* (Plate I F) is much more complete than that of either *stictigaster* and *sierrae* (Plate I A and B). Of the Camagüey subspecies, *parasphex* and *ophiplacodes* have orange scales in Zones 3 and 5, and *parasphex* has the throat pattern reticular (Plate I H). The throat pattern is much more complete in *lipomator* than it is in *ophiplacodes* (Plate I G); the throat pattern of *lucianus* and *lipomator* are rather comparable (Plate I F and I), but the presence of a third anterior V in the pattern of the latter differs from the mere indication of this feature by a pre-V bar or spot in *lucianus.* In addition, the throat pattern of *lucianus* is bold and diagrammatic on a clear yellow ground. Other pigmental and pattern differences distinguish *L.s. lipomator* from both the Pinar del Río and Camagüey subspecies.

In size, *L.s. lipomator* is the smallest subspecies (largest male 68 mm), with *ophiplacodes* (largest male 73 mm) closest in size; both these subspecies are represented by somewhat limited material. If the small size of *lipomator* is real, it will serve as an additional difference between it and *naranjoi,* which is the largest of the named subspecies.

Remarks. The type series of *L.s. lipomator* was collected behind the Motel Los Caneyes, 3 kilometers west of the city of Santa Clara. The area where the few specimens were taken is serpentine savanna with low native vegetation although there has been some eucalyptus planted nearby. The lizards live beneath rocks and leaves among grass and low vegetation. The collectors were impressed with the scarcity of *L.s. lipomator* at the type locality; the lizards were not observed before 1000 hours and even then were far from abundant or easy to secure.

A single young *L. cubensis cubensis* was taken along with the type series of *L.s. lipomator;* the original ecology of the type locality seems far more suitable for *L. stictigaster* than for *L. cubensis* and it seems possible that disturbance by man of the primal sparse floral cover (i.e., the planting of eucalyptus to offer some shade) has been instrumental in allowing *L. cubensis* from some nearby area to occur syntopically with *L. stictigaster.*

The known occurrence of *L.s. lipomator* lies about 70 kilometers airline north and northeast of the closest subspecies *(L.s. naranjoi)* and is separated from *naranjoi* at least in part by the Sierra de Trinidad. The range of *naranjoi* is predominantly coastal, whereas that of *lipomator* is on the serpentine savannas of central Las Villas. The nearest subspecies to the east is *ophiplacodes,* which also occurs in the serpentine savannas of Camagüey Province, some 240 kilometers southeast of Santa Clara. *L. stictigaster* has as yet not been recorded from the western half of Camagüey Province, in the Llanura de la Trocha. *L. cubensis cubensis* is known from several stations in this intermediate region (Schwartz, 1959:99 and 107). To the west, *L. stictigaster* is not known nearer to the station for *L.s. lipomator* than 350 kilometers airline (vicinity of Las Pozas, Pinar del Río Province; Schwartz, 1960: 127), and the intervening area is occupied by *L.c. cubensis.*

For the population of *L. stictigaster* which occurs to the north of the Sierra Maestra in Oriente Province we propose the name, in translation into Greek of the type locality,

Leiocephalus stictigaster celeustes, new subspecies

Holotype. IB 1182, an adult male, from Contramaestre, Oriente Province, Cuba, one of a series collected in May 1947, by native collector.

Paratypes. IB 1180-81, IB 1183-84, IB 1186, IB 1188-95, ASFS VIII78-82, MCZ 92021-25, NMC 9639-43, +13 specimens in the UH, same data as holotype; IB 610, Limonar, 11 km S Bueycito, Bayamo, Oriente Province, Cuba, 13 July 1966, J. de la Cruz; UH (two specimens), Finca El Palmarito, El Jobo, Bayamo, Oriente Province, Cuba, no date, C.T. Ramsden; MBZH 130, Bayamo, Oriente Province, Cuba, no date, C.T. Ramsden; ASFS VII755-62, IB 1232-35, MFP – 4 specimens, Jaraquilo, Bayamo, Oriente Province, Cuba, 15 March 1967, O.H. Garrido, M.L. Jaume.

Definition. A subspecies of *L. stictigaster* characterized by a lined dorsum with prominent dark brown to black blotches in Zone 3, Zone 5 (lateral band) with bold short brown to black longitudinal dashes, Zones 4 and 6 broad, pale and very conspicuous, throat in both sexes with a very bold and coarse dark brown to black pattern on a paler ground, chest and often anterior portion of venter heavily and coarsely stippled with large brown to black dots, postocular spot absent, size very large (snout-vent length to 100 mm in males, 80 mm in females), and parietal scales usually not in contact.

Distribution. Known only from west-central Oriente Province, Cuba, along the northern flank of the Sierra Maestra, from the vicinity of Bueycito in the west to Contramaestre in the east (Figure 1).

Description of holotype. An adult male with the following measurements (in millimeters) and counts: snout-vent length 90, tail 133, snout to anterior border of tympanic opening 19.2, head width 15.2, supraocular scales 6/6, loreals 5, temporals 13, enlarged auricular scales 3/1; median head scales 4, prefrontal row complete, 3 scales, frontoparietal row complete, 5 scales, supraorbital semicircles complete, parietal scales not in contact, dorsal crest scales occiput to vent 55, dorsal crest scales occiput to axilla 21, scales around one half body at midbody 21, fourth toe subdigital tricarinate scales 24/24.

Our comments on the color of *L.s. celeustes,* both holotype and paratypes, are based entirely on the preserved material. As preserved, the holotype is dark brown above, with Zone 1 not separated from Zone 2. Along the lateral margins of Zone 2 is a longitudinal series of pale areas, usually involving the basal portions of one or two scales, which delimit the lateral margins of Zone 2; Zone 3 has dark brown to black markings in its entire length from the neck to near the groin; Zone 4 is wide and pale, involving two to three scales; Zone 4 continues above the groin onto the upper side of the tail where it delimits the lateral margins of about seven brown subcircular spots on the base of the tail; Zone 5 is broad and brown and marked from the neck to the groin with bold dark brown to black longitudinal dashes; Zone 6 is bold and paler than Zone 4 and extends from the tympanic opening to the groin, sharply delimiting the lower margin of Zone 4; Zone 7 (lower sides) is dark brown grading rather sharply into the pale venter. The upper surface of the head is presently pale tan with scattered minute black flecks. The hindlimbs are tan to medium brown and heavily marked with dark brown lines, spots, or dashes which also involve the toes; the forelimbs are brown and apparently without darker brown markings. The postocular spot is not set off from the balance of Zone 5; its position is indicated by a hollowed rectangle with dark dorsal and ventral margins. The throat is pale, with a pattern consisting of a coarse dark brown inverted U, followed by four longitudinal dark lines and the remnants of two additional dark lines, and preceded by two dark dots anterior to the bend of the U. The longitudinal throat lines extend onto the chest where they become involved in a pectoral area of coarse dark spots (Plate I J). The venter, except for the pectoral spots, is immaculate. There are some scattered brown flecks on the underside of the forelimbs but the hindlimbs are immaculate beneath. The tail, posterior to the subcircular dorsal spots mentioned above, is marked by a series of chevrons which become progressively more blotchlike posteriorly.

Variation. The paratypic series consists of 28 males and 33 females. The largest male (ASFS VII755) has a snout-vent length of 100 mm, a truly large *L. stictigaster*, and the largest females (IB 1189 and MCZ 92024) have snout-vent lengths of 80 mm. Dorsal crest scales in occiput-vent length (combined data for both sexes) average 53.6 (47-58) and dorsal crest scales in occiput-axilla length average 20.4 (16-26). One half scales at midbody average 22.0 (20-26), loreals 4.5 (2-8), temporals 12.2 (10-15), subdigital tricarinate scales on the fourth toe 23.2 (20-26). The parietals are slightly more often (54 percent) not in contact, the supraorbital semicircles are more often (86 percent) complete. The prefrontal row is composed of 3 to 5 scales (mode strongly 3) and is complete in 59 of 61 lizards; median head scales vary from 3 to 7, with a mode of 4 (48 lizards); the frontoparietal row is composed of 3 to 7 scales with a mode of 5 (30 lizards) and is more often complete (44 of 56 lizards).

The dorsal tones and pattern described for the holotype are to be found also in the male paratypes. The series from Contramaestre itself is somewhat discolored, but the distinct zonation, black or dark brown markings in Zone 3, and broad and pale Zones 4 and 6 are common features. Few males other than the holotype have any pale markings on Zone 2. The lateral band (Zone 5) regularly is marked with short dark brown to blackish dashes. The hindlimbs do not always show the dark dashes on a paler ground, but the apparent absence of these markings may be due to the discoloration of the specimens. The most variable features are the throat and chest patterns. The pattern as described in the holotype approaches the lower extreme as far as intensity and completion is concerned. The markings consist usually of a complete V or U with its apex pointed anteriorly, followed by an incomplete V or U (whose apex is usually missing) joined to a pair of paramedian lines. There may also be a single transverse bar or pair of spots before the V's apex near the chin. The markings are always extremely bold and coarse. Often the posterior portions of the paramedian throat lines are obscured by additional dark pigment in the form of more longitudinal lines (as in the type) or merely large blotches of dark pigment. The throat pattern grades into the heavily and coarsely spotted chest; the under surfaces of the forelimbs are also finely to coarsely flecked or dotted with brown. The chest spotting may extend over the anterior third or half of the venter and in some males the entire venter is dotted, along with the undersides of the hindlimbs. The postocular spot is represented only by its dark dorsal and ventral margins – i.e., it is a hollow rectangle whose central color does not differ from that of the balance of Zone 5. The tails of some males are patterned like that of the holotype, but others have the more orthodox pattern of chevrons typical of the species.

Females are like males dorsally, but in adult females there is a tendency for Zone 4 to be less conspicuous and more darkly pigmented. The throat patterns of females are as bold and coarse as are those of the males and often have even more deposition of accessory dark pigment between and adjacent to the paramedian lines; the second V is rarely complete anteriorly. The chest is heavily spotted with black or brown, and the dots at times are fused into short longitudinal lines. The sides of the venter likewise are heavily and coarsely spotted with dark. Females lack dark dashes in the lateral bands (Zone 5) or at least have them much suppressed;

the well preserved female from Finca Palmarito has the lateral dashes barely discernible whereas in the Finca Palmarito male the dashes are bold and conspicuous, as are also the dark dashes on the hindlimbs and toes. Since there is little difference in pattern between adults of both sexes, juveniles of both sexes are not patterned differently from their corresponding adults.

Comparisons. The bold and coarse dark throat pattern of *L.s. celeustes* distinguishes the subspecies from *stictigaster, sierrae, exotheotus* and *astictus,* which have other sorts of patterns. The throat of *celeustes* resembles that of *naranjoi, lipomator, parasphex, ophiplacodes,* and *lucianus,* all of which have in essence two pairs of V's followed by longitudinal paramedian lines. The throat pattern of *celeustes* differs from that of *parasphex* which is additionally reticulate on a dark ground and is much bolder and darker than those of *ophiplacodes, naranjoi* and *lipomator.* Both *ophiplacodes* and *naranjoi* have the pattern reduced and often very much fragmented in contrast to the much more fully expressed pattern in *celeustes,* which also has much additional pigment involved with the longitudinal lines. Most close resemblance in throat pattern is between *celeustes* and *lucianus* (Plate I, I and J); however, the pattern in the former is even more extensive and coarse than that of the latter. The two subspecies differ also in that *celeustes* has the lateral bands with dark included dashes, a feature which is suppressed in *lucianus.* The size of *celeustes* is much greater than that of *lucianus,* in which form males reach a maximum snout-vent length of 78 mm and females 58 mm. Doubtless there are strong color differences between these two subspecies which are presently unknown because of lack of pigmental data on *celeustes.* The throats of *lucianus* and *celeustes* are comparable only grossly; the pattern of *celeustes* throats is much more extensive and coarse than the equally bold but much finer pattern of *lucianus.*

L.s. celeustes differs from *stictigaster, sierrae, lucianus,* and *ophiplacodes* in having the parietal scales more often not in contact; in this feature *celeustes* resemble *exotheotus, astictus, naranjoi, lipomator,* and *parasphex.* The modality of lack of parietal contact is not strong (54 percent) in *celeustes,* however. In having the semicircles complete, *celeustes* resembles all subspecies except *stictigaster* which has the semicircles modally incomplete. The only subspecies which approaches *celeustes* in size is *naranjoi* (males 100 in the former, 87 in the latter; females 80 in the former, 68 in the latter). The contrast in size between the very large *celeustes* and the very small *exotheotus* (males to 77 mm, females to 61 mm) is indeed striking. There are no differences between *celeustes* in scale counts, or relationships between head scales, and the other subspecies.

Remarks. L.s. celeustes occupies the southern portion of the Cauto-Alto Cedro Plain (Llanura del Cauto-Alto Cedro; Marrero 1951: 636 *et. seq.*). This region, confined to Oriente Province, is confluent on the north with the Camagüey-Tunas-Holguĩn Subregion. The latter area is occupied (at least in part) by *L.s. ophiplacodes.* In essence, the Cauto-Alto Cedro Plain encompasses the lowlands associated with the Rĩo Cauto in western Oriente. The plain has little relief and is presently mainly under cultivation, although it was previously at least partially heavily forested (Marrero 1951: 640). The precise distribution of *L.s. celeustes* is unknown; apparently the subspecies occurs not only on the lowlands at the base of the Sierra Maestra but also on the adjacent foothills and lower slopes of the range.

There apparently is another population of *L. stictigaster* in southern Oriente Province. A single female (MJ 427), collected by the junior author, from the upper slopes of Gran Piedra, in the Sierra de la Gran Piedra, at an elevation of about 3500 feet (1,007 meters), indicates that the species occurs in this mountain range and also represents a much higher occurrence for *L. stictigaster* than previously reported. The lizard has a snout-vent length of 61 mm, 50 dorsal crest scales between occiput and vent, 22 scales between occiput and axilla, 4 prefrontals in a complete row, 6 median head scales, frontoparietal row damaged, 6 loreals, 13 temporals, 23/22 fourth toe scales, 6/6 supraoculars, and complete semicircles. The parietal region is destroyed. Dorsally there is nothing distinctive about the specimen; the throat pattern however is quite different from that of the geographically closest subspecies (*celeustes*) in that there are remnants of two V's and four posterior longitudinal lines, all in a smudged or diffuse gray rather than the bold and coarse black or dark brown of female *celeustes.* Gran Piedra lies about 80 kilometers airline southeast of Contramaestre, the closest known locality of *celeustes.* More material from the Sierra de la Gran Piedra would be instructive. The senior author has spent many days collecting at various elevations on Gran Piedra and never encountered this species (nor any other *Leiocephalus)* on the higher slopes of the mountain. However, considering the usually cool diurnal temperatures and general fog, mist and rainy conditions which normally prevail there, lack of contact with any *Leiocephalus* on Gran Piedra is not especially surprising.

The population of *L. stictigaster* on the northern Oriente coast at Gibara in some ways resembles *L.s. lucianus* from Playa Santa Lucĭa on the northern coast of Camagüey Province, but the former differs from the latter in several significant ways and for it we propose the name

Leiocephalus stictigaster gibarensis, new subspecies

Holotype. IB 1236, an adult male, from Gibara, Oriente Province, Cuba, one of a series collected 13 March 1967 by Orlando H. Garrido and Miguel L. Jaume.

Paratypes. ASFS VII763-67, IB 1237-39, NMC 9708-9711, MFP – 4 specimens, same data as holotype; IB 317, IB 329-35, same locality as holotype, no date. O.H. Garrido.

Definition. A subspecies of *L. stictigaster* characterized by a lined dorsum with black markings in Zone 3, Zone 5 (lateral band) with short brown to black longitudinal dashes and scattered green scales on a blackish terra-cotta ground, throat pattern black and conspicuous on a clear pale yellow to cream ground and consisting of bold remnants of a pair of V's with their apices directed anteriorly and a pair of paramedian lines, chest and venter marked with brown to reddish dots, postocular spot absent, parietal scales modally in contact and supraorbital semicircles modally incomplete.

Distribution. Known only from the type locality (Fig. 2).

Description of holotype. An adult male with the following measurements (in millimeters) and counts: snout-vent length 75, tail 104, distal half regenerated, snout to anterior border of tympanic opening 17.2, head width 14.3, supraocular scales 6/6, loreals 6, temporals 11, enlarged auricular scales 3/3; median head

scales 4, prefrontal row complete, 3 scales, frontoparietal row complete, 5 scales, supraorbital semicircles incomplete, parietal scales in contact, dorsal crest scales occiput to vent 48, dorsal crest scales occiput to axilla 21, scales around one half body at midbody 20, fourth toe subdigital tricarinate scales 23/23.

Dorsally, the holotype is a conspicuously longitudinally lined lizard, with a generally pale aspect. The colors of the various dorsal zones follow. Zone 1: brown, slightly narrower than Zone 2 and with remnants of dark markings on the median crest scales; Zone 2: pale tan, contrasting both with the darker Zone 1 above and the darker Zone 3 below; Zone 3: darker brown than Zone 1 and with irregular longitudinal markings from about the level of the forelimbs posteriorly onto the top and sides of the tail where the markings become distinctly lineate and form a series of more or less longitudinal or diagonal dashes; Zone 4: a wide creamy band, about equal in width to Zone 3, extending from behind the eye to above the hindlimb insertions; Zone 5: brown, with both upper and lower margins marked with terra-cotta scales, and the interior of the band with scattered black and green scales; Zone 6: slightly narrower than Zone 4 and creamy in color; Zone 7: brown with scattered black and green scales like Zone 5. The head is immaculate brown and the postocular spot is absent, its position indicated only by dark brown upper and lower margins of Zone 5 in the temporal region. The limbs are brown above, heavily marked with black. The ventral color is pale yellow or creamy; the throat pattern consists of two V's, with their apices pointed anteriorly. The more anterior V is fragmented medially, and the more posterior V has a distinct apical break, on either side of which the arms of the V are joined to the pair of black paramedian lines. There is an irregular pair of black dots preceding the broken apex of the anterior-most V. The paramedian lines continue onto the chest which is heavily spotted with black (Plate I K), and black dots continue over the entire venter, although the more ventrolateral spots in life were more brownish to red. The undersides of both fore- and hindlimbs are dotted with reddish spots, and the underside of the tail has some grayish spots near its base. The ventral aspect of the holotype is one of distinct and discrete throat pattern and belly dotting on a clear pale ground. There are some reddish dots on the sides of the tail.

Variation. The paratypic series consists of 13 males and 11 females. The largest male (IB 335) has a snout-vent length of 84 mm and the largest female (IB 333) a snout-vent length of 71 mm. Dorsal crest scales in occiput-vent length (combined data for both sexes) average 50.5 (46 - 55) and dorsal crest scales in occiput-axilla length average 19.5 (15 - 24). One half midbody scales average 22.5 (20 - 25), loreals 5.0 (3 - 7), temporals 11.3 (9 - 14), subdigital tricarinate scales on the fourth toe 23.0 (21 - 27). The parietals are more often (91 percent) in contact and the semicircles are more often (88 percent) incomplete. The prefrontal row is composed of 3 to 5 scales (more strongly 3) and is always complete; median head scales vary from 4 to 7, with a mode of 4 (10 of 20 lizards); the frontoparietal row is composed of 3 to 5 scales with a mode of 5 (15 lizards) and is more often complete (18 of 20 lizards). Noteworthy are the high incidences of parietal contact and incomplete semicircles; these features will be discussed below.

In dorsal color and pattern, the male paratypes are very like the description of the holotype. The contrasting pale and dark longitudinal zones with a wide Zone 4, dark Zone 5 with included black markings, and dark Zone 3 with lineate dark markings extending onto the tail are all common features of the adult male paratypes. There is some variation in the throat pattern and the ventral dotting. The gular pattern is always bold and black on a clear pale ground and always consists of remnants of two V's and a pair of paramedian lines; most specimens additionally have the anterior V preceded by a black bar or pair of dots. The V's themselves may be grossly fragmented and the paramedian lines also may be broken; even in such instances, there is no loss of intensity of the throat pattern pigment but rather only hiatuses in the continuity of the lines themselves. The chest is usually heavily marked with large black spots and the venter is usually heavily dotted with black to brown dots; however, one adult male (ASFS VII764) lacks ventral dotting completely and others do not demonstrate it on the central portion of the belly. Of two young males (snout-vent lengths 33 and 39 mm) one has the belly stippled and the other has the belly virtually immaculate. Apparently ventral dotting is not an ontogenetic feature in *L. s. gibarensis.*

Females resemble males in dorsal color and zonation, but Zones 4 and 6 seem to be even brighter (more white than cream) in smaller females than they do in the tiny males. Zone 3 has the included black markings often practically confluent with one another, to give an almost entirely black Zone 3. Zones 5 and 7 usually have black to dark brown longitudinal dashes, or this darker pigmentation may be limited to the upper and lower margins in Zone 5 and be even more irregular in Zone 7. Female throat patterns are identical to those of males in both pigmentation and variability; the venters of females are heavily punctate with coarse dark brown to black spots; females lack red dots in Zones 5 and 7 nor do they occur on the tail and sides of the venter as in males.

Comparisons. When the junior author collected the first series of *L. s. gibarensis*, he considered that they represented *L. s. lucianus* from Playa Santa Lucĭa in extreme eastern Camagüey Province. The two subspecies are indeed very similar and the most trenchant comparisons are between them, rather than between *gibarensis* and other subspecies. Perhaps the most striking difference in scalation between *lucianus* and *gibarensis* is the reversal of the condition of the supraorbital semicircles. In *lucianus*, the semicircles are more often complete (72 percent) whereas in *gibarensis* they are more often incomplete (88 percent). In fact, *gibarensis* differs from all other subspecies except nominate *stictigaster* in modally having the semicircles incomplete, and in *stictigaster* the incidence is much lower (60 percent) than in *gibarensis* (88 percent). *L. s. gibarensis* reaches a larger size than *L. s. lucianus*, with males of the former reaching snout-vent lengths of 84, males of the latter 78; the difference is even more obvious in females, since female *gibarensis* reach snout-vent lengths of 71 mm and female *lucianus* 58 mm. Both sexes in both subspecies are represented by adequate series. The throat pattern of *gibarensis* resembles that of *lucianus* in that both are bold and black on a clear ground (Plate I,I and K,), but we have the impression that the pattern is more fragmented in *lucianus* than in *gibarensis*. Ventral dotting is variable in males of both subspecies. The dorsal

coloration of *lucianus* is in general darker than that of *gibarensis*, but both have very strikingly lineate dorsal zonation.

From the balance of the subspecies, *gibarensis* differs from *astictus, naranjoi, parasphex* and *ophiplacodes* in usually having the venter dotted with darker. Since the parietals are more often in contact in *gibarensis*, this subspecies differs from *exotheotus, astictus, naranjoi, lipomator, parasphex* and *celeustes*, all of which modally have the parietals separated. Of the subspecies which usually have the parietals in contact *(stictigaster, sierrae, lucianus, ophiplacodes)* none has so high an incidence (91 percent) as does *gibarensis* (58 percent to 68 percent in the other subspecies). In having the semicircles modally incomplete, *gibarensis* differs from all other subspecies except *stictigaster:* the latter subspecies has 60 percent of the individuals with incomplete semicircles whereas *gibarensis* has 88 percent with incomplete semicircles. *L. s. gibarensis* differs from *stictigaster, sierrae, exotheotus* and *astictus* in having a more complete throat pattern and from *parasphex* in lacking a reticulate throat pattern. As far as the remaining subspecies are concerned *(naranjoi, lipomator, lucianus, ophiplacodes, celeustes)* all basically have similar throat patterns (two V's and a pair of paramedian lines) but they differ *intra se* in integrity of the lines, the clarity and boldness of the lines themselves, and the presence or absence of clouding in the throat ground color. As pointed out above, *gibarensis* most closely resembles *lucianus* in most features of throat design.

Remarks. The type series of *L. s. gibarensis* was secured by the junior author and Miguel L. Jaume in a xeric area on a substrate of *diente de perro* limestone and pieces of limestone. The vegetation was low with scattered shrubs.

Gibara, the type locality of *L. s. gibarensis,* lies on the north-central Oriente coast. This only station for *L. s. gibarensis* lies about 100 kilometers airline southeast of the known range of *L. s. lucianus* (at Playa Santa Lucĭa on the northern coast of Camagüey Province) and about 90 kilometers due north of the range of *L. s. celeustes.* There are no striking physiographic boundaries between occurrences of *gibarensis* and *lucianus,* but the broad interior basin of the Rĭo Cauto separates *gibarensis* from *celeustes.* Presumably *L. stictigaster* will be found to occur elsewhere along the northern littoral between Playa Santa Lucĭa and Gibara.

DISCUSSION

Table 1 presents measurements and scale counts for the eleven subspecies of *L. stictigaster,* arranged more or less from west to east. Size, parietal contact and semicircle completion have been discussed in the descriptions of the new subspecies. Body scutellation in the various subspecies is of little significance in differentiating the forms. Means in dorsal crest scales between occiput and vent vary from 48.7 *(exotheotus)* to 57.2 *(ophiplacodes).* Means of one half midbody scales range from 22.0 (*astictus)* to 27.2 *(ophiplacodes),* of loreals between 4.5 *(exotheotus)* to 7.3 *(lipomator),* of temporals between 11.0 *(astictus)* and 13.1 *(ophiplacodes),* and of fourth toe subdigital tricarinate scales between 22.2 *(exotheotus)* and 24.3 *(lucianus).* Of the eleven subspecies, *ophiplacodes* lies at the upper extreme of means in three counts and *exotheotus* at the lower extreme in three counts. All subspecies normally have the prefrontal and frontoparietal rows complete. The prefrontal row is almost always composed of 3 scales. The median head scales are

modally 4 in all subspecies, and often strongly so (for example, 45 of 52 *L. s. stictigaster* have 4 medians). All subspecies but one *(ophiplacodes)* modally have 5 frontoparietals; in *ophiplacodes* the mode is 7 (seven of 10 specimens).

The distribution of *L. stictigaster* is now known to encompass practically the entire length of Cuba and the Isla de Pinos. Populations appear to be disjunct with the noteworthy exceptions of those in Pinar del Rĩo Province (*stictigaster* and *sierrae*, which are known to intergrade). The only provinces whence *L. stictigaster* remains unreported are Habana and Matanzas; the latter is particularly poorly explored and the species may yet be encountered there. In addition to the eleven populations already recognized nomenclatorially, there is another (Gran Piedra in Oriente Province) whose status remains undetermined. It is more than likely that still other isolated populations of *L. stictigaster* remain to be discovered, and the detailed distribution of several of the eastern forms is as yet poorly known.

There has been no previous evidence that *L. stictigaster* and *L. cubensis* were sympatric or syntopic. In all the collecting done in Cuba by the senior author between 1954 and 1960, one species or the other was found at any given locality, and the assumption was made that these two closely related species were completely allopatric and allotopic. The senior author pointed out, however, that in some cases (such as *lucianus* at Playa Santa Lucĩa) populations of L. *stictigaster* occur within the much broader range of *L. cubensis* (Schwartz 1960:103). At this particular locality, *L. macropus* and *L. carinatus* occur in the immediate vicinity (although *L. cubensis* apparently does not) but not syntopically with *L. stictigaster.*

The junior author for the first time collected *L. stictigaster* and *L. cubensis* together in the Trinidad area. The situation at the locality of syntopy is obviously a case of a marginal one for *L. stictigaster* in what otherwise is typical *L. cubensis* habitat. The area of syntopy lies along the Rĩo Guaurabo near Trinidad. The habitat presents a quite different picture from the more arid coastal areas about Casilda which are typical for *L. stictigaster* through much of its range, but *L. s. naranjoi* has extended its range to the Rĩo Guaurabo from the south. Both species were collected, but the majority were *L. cubensis,* as might be expected in such a region of contact. Interaction of the two species under such circumstances would well repay careful study.

Although we are not familiar with the precise details, *L. cubensis cubensis* and *L. stictigaster naranjoi* occur very close to one another at a second Las Villas locality, in the vicinity of Juraguá. We have examined five *L. cubensis* (IB 666-70) from Cinco Tiras, near Juraguá. It seems probable that this immediate area supports both species but that each is confined to its own ecological niche, except for marginal situations as near Trinidad. The specimens of *L. c. cubensis* show no tendencies toward *L. stictigaster;* in this area, *L. cubensis* differs conspicuously from *L. s. naranjoi* in having a very dark and heavily mottled and lined throat pattern in contrast to the very restricted pattern in Juraguá *L. s. naranjoi.*

An additional area of contact between *L. cubensis* and *L. stictigaster* occurs at the type locality of *L. s. lipomator.* Here, the junior author secured one young *L. cubensis* with the type series of *L. s. lipomator.* The area has been described in the discussion of the latter subspecies and a suggestion has been made concerning the

reasons for occurrence of *L. cubensis* in an area which has been ecologically disturbed.

Along the coast between Trinidad and Cienfuegos, and at Punta Casilda, the senior author collected only *L. cubensis* in xeric habitats which are those preferred by *L. stictigaster.* It is doubtful that the Casilda population of *L. s. naranjoi* is presently in genetic contact with the Juraguá population, but the separation may have been sufficiently recent to have prevented these two populations from achieving a degree of differentiation worthy of nomenclatorial separation from one another. Despite a three-day stay at Paso Caballo, which lies across the narrow mouth of the Bahĩa de Cienfuegos, on whose other side occurs the Juraguá population of *L. s. naranjoi,* the senior author encountered neither *L. stictigaster* nor *L. cubensis,* but only *L. carinatus* in coastal situations. Such absences, especially that of *L. cubensis,* are extremely puzzling; they also serve to point out once more the decidedly erratic distribution of *L. stictigaster* throughout much of its range.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

CRAB-LIKE ANOMURA AND BRACHYURA (CRUSTACEA: DECAPODA) FROM SOUTHEASTERN ALASKA AND PRINCE WILLIAM SOUND

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Department of the Secretary of State

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CRAB-LIKE ANOMURA AND BRACHYURA (CRUSTACEA: DECAPODA) FROM SOUTHEASTERN ALASKA AND PRINCE WILLIAM SOUND[1]

JOSEPHINE F.L. HART*

During the summer of 1961, the National Museum of Canada collected biological material in the coastal waters of southeastern Alaska and Prince William Sound. Lists of stations, with details of collecting data and maps showing the positions of the stations, have already been published by Bousfield and McAllister (1962).

I have examined about 100 specimens of eight species of crab-like Anomura and 1,200 of nineteen species of Brachyura which were obtained by this expedition. Of these, one Anomuran, *Petrolisthes eriomerus* Stimpson, was obtained farther north and west than had previously been reported in the literature, as were seven species of Brachyura: *Pugettia producta* (Randall), *P. richii* Dana, *Cancer gracilis* Dana, *Lophopanopeus bellus bellus* (Stimpson), *Pinnixa littoralis* Holmes, *Hemigrapsus nudus* (Dana), and *H. oregonensis* (Dana). *Petrolisthes eriomerus, Pugettia producta,* and *P. richii* have not been previously reported from Alaskan waters.

The list of specimens, with the station numbers and distribution data, follows.

ANOMURA

Hapalogaster grebnitskii Schalfeew, 1892

8 specimens from the intertidal zone at stations A87 and A115.

Distribution: Bering Sea to Humboldt Bay, California at depths to 45 fathoms (Schmitt 1921). Kamchatka, Sea of Okhotsk and Sea of Japan (Makarov 1938).

Hapalogaster mertensii Brandt, 1850

27 specimens from the intertidal zone or in the stomachs of jigged fish at stations A3, A57, A87, A92, A125, A131, A147, A151, A168, A171-172, and A173.

Distribution: Atka Island, Aleutian Islands, Alaska, to Puget Sound, Washington at depths to 19 fathoms (Rathbun 1904).

Oedignathus inermis (Stimpson, 1860)

2 specimens from the intertidal zone at stations A171-172.

Distribution: Unalaska, Alaska, to Pacific Grove, California (Rathbun 1904). Japan (Makarov 1938). Miyake (1957) obtained one specimen at 25 fathoms in Japan, but in British Columbia they are common in the intertidal zone.

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Acantholithodes hispidus (Stimpson, 1860)

2 specimens at stations A85 and A173, one in a gill net and one in the stomach of a jigged fish.

Distribution: Bering Sea, Alaska, to Monterey, California at depths to 73 fathoms (Schmitt 1921).

Cryptolithodes sitchensis Brandt, 1853

3 specimens from the intertidal zone at stations A6 and A175.

Distribution: Sitka, Alaska, to Pacific Grove, California (Rathbun 1904). To 7 fathoms (Makarov 1938).

Cryptolithodes typicus Brandt, 1849

1 specimen from the stomach of a jigged fish at station A173.

Distribution: Unalaska, Alaska, to Monterey, California at depths to 25 fathoms (Holmes 1900).

Phyllolithodes papillosus Brandt, 1849

1 small specimen from the stomach of a jigged fish at station A173.

Distribution: Unalaska, Alaska, to Monterey, California at depths to 16 fathoms (Rathbun 1904).

Petrolisthes eriomerus Stimpson, 1871

61 specimens from the intertidal zone at stations A3, A168 and A175.

Distribution: The presence of this species at Klokachef Island, Chichagof Island (57°25′ N, 135°52′ W), Alaska, is an extension of range from Langara Island, Queen Charlotte Islands, British Columbia (Hart 1953). The southern known limit is La Jolla, California (Haig 1960) at depths to 47 fathoms.

BRACHYURA

Oregonia gracilis Dana, 1851

17 specimens from the intertidal zone from stomachs of jigged fish and from dredges of 20 to 30 fathoms at stations A3, A6, A7, A69, A81, A87, A100, A106, A165, A169, and A173.

Distribution: Bering Sea to Monterey, California (Rathbun 1925) at depths to 212 fathoms (Garth 1958). Japan.

Hyas lyratus Dana, 1851

8 specimens from the stomachs of jigged fish or dredged from 11-38 fathoms at stations A45, A69, A103, A116, and A119.

Distribution: Bering Sea to Puget Sound, Washington at depths of 5 to 350 fathoms (Rathbun 1925).

Chionoecetes bairdi Rathbun, 1925

6 specimens dredged from 8 to 66 fathoms at stations A124, A143, and A144.

Distribution: Bering Sea to Puget Sound, Washington (Garth 1958) at depths to 259 fathoms (Rathbun 1925).

Pugettia gracilis Dana, 1851

388 mainly juvenile specimens from the intertidal zone, a few from the

stomachs of jigged fish or dredged from 3 to 30 fathoms at stations A3, A6, A7, A8, A15, A16, A17, A22, A25, A48, A71, A75, A80, A81, A84, A87, A90, A91, A92, A96, A115, A121, A125, A129, A131, A147, A151, A161, A164, A168, A171-172, A174, and A175.

Distribution: Dutch Harbor, Unalaska, to Monterey, California at depths to 62 fathoms (Garth 1958).

Pugettia producta (Randall, 1839)

5 specimens from the intertidal zone at stations A2 and A175.

Distribution: The occurrence of this species off Prince of Wales Island, (55°26′ N, 133°18′ W), Alaska, is an extension of range from Queen Charlotte Islands, British Columbia (Hart 1940). The southern known limit is Ascuncion Point, Lower California, Mexico (Garth 1958) at depths to 40 fathoms.

Pugettia richii Dana, 1851

6 small specimens from the intertidal zone at station A6.

Distribution: The occurrence of this species from the southern tip of Prince of Wales Island (54°43′ N, 132°17′ W), Alaska, is an extension of range from the Queen Charlotte Islands, British Columbia (Hart 1940). The known southern limit is San Geronimo Island, Lower California, Mexico (Garth 1958) at depths to 53 fathoms.

Chorilia longipes Dana, 1851

2 specimens from the stomachs of jigged fish at stations A169 and A173.

Distribution: Shumagin Bank, Alaska, to Santa Rosa Island, California (Garth 1958). 18 to 650 fathoms (Rathbun 1925). Japan.

Telmessus cheiragonus (Tilesius, 1813)

45 specimens, mostly juveniles, from the intertidal zone, from the stomachs of jigged fish, and dredged from stations A3, A8, A30, A48, A57, A69, A75, A81, A86, A87, A92, A96, A105, A117, A120, A131, A147, A151, A175.

Distribution: Bering Sea to northern California (Holmes 1900). North coast of Siberia, Kamchatka, and Kurile Islands (Holmes 1900). To 20 fathoms (Rathbun 1904).

Cancer branneri Rathbun, 1930

8 specimens (1 incomplete) from the intertidal zone, from stomachs of jigged fish, or dredged at 6 to 30 fathoms at stations A161, A165, A169, A174, and A175.

Distribution: Granite Cove, Port Althrop, Cross Sound, Alaska, to Santa Catalina, California at depths to 40 fathoms (Rathbun 1930).

Cancer gracilis Dana, 1852

2 immature males from the intertidal zone and from the stomach of a jigged fish at stations A96 and A161.

Distribution: The occurrence of this species in Prince William Sound, (60°46′ N, 146°31′ W), Alaska, is considerably farther north and west

than the previous record of Prince of Wales Island (Rathbun 1930). The southern known limit is Sebastian Viscaino Bay, Lower California, Mexico (Phillips 1939). To 78 fathoms (Butler 1961).

Cancer magister Dana, 1852

16 specimens, immature and juveniles, from the intertidal zone at stations A7, A30, A67, A83, A136, and A140.

Distribution: Tanaga Island, Aleutian Islands, Alaska (Scheffer 1959), to Magdalena Bay, Lower California, Mexico (Phillips 1939). To 98 fathoms (Butler 1961).

Cancer oregonensis (Dana, 1852)

148 specimens from the intertidal zone or from the stomachs of jigged fish at stations A3, A6, A7, A8, A15, A23, A48, A57, NMC61-66, A68, A75, A81, A83, A86, A87, A91, A92, A96, A115, A131, A136, A147, A151, A161, A164, A168, A171-172, and A173.

Cancer productus Randall, 1839

5 specimens from the intertidal zone and 1 from the stomach of a jigged fish at stations A3, A7, A74, A97, and A174.

Distribution: Kodiak, Alaska, to Laguna Beach, California at depths to 43 fathoms (Rathbun 1930).

Lophopanopeus bellus bellus (Stimpson, 1860)

109 specimens from the intertidal zone at stations A3, A8, A86, A87, A91, A92, A96, A131, A168, and A175.

Distribution: The occurrence of this species in Resurrection Bay (59°56′ N, 149°19′ W) is farther west than the previous record of Prince William Sound, Alaska (Rathbun 1930), to Point Sur, California, in the intertidal zone (Menzies 1948).

Pinnixa littoralis Holmes, 1894

1 immature female from a razor clam, *Siliqua patula* (Dixon), from the intertidal zone at station A81.

Distribution: This specimen, from Orca Inlet, Hawkins Island, Prince William Sound, Alaska (60°33′ N, 145°48′ W), is considerably farther north than Rathbun's (1918) record from Sitka, Alaska. The known southern limit is San Diego, California at depths to 50 fathoms (Rathbun 1918).

Pinnixa occidentalis Rathbun, 1893

4 specimens from the intertidal zone and between 28 and 30 fathoms at stations A83 and A84.

Distribution: Unalaska, Alaska, to Magdalena Bay, Lower California, Mexico at depths to 238 fathoms (Rathbun 1918).

Pinnixa schmitti Rathbun, 1918

34 specimens from the intertidal zone at stations A3, A8, A15, A23, A27, A164, and A174.

Distribution: Unalaska, Alaska, to San Francisco Bay, California at depths to 80 fathoms (Rathbun 1918).

Hemigrapsus nudus (Dana, 1851)

77 specimens from the intertidal zone at stations A18, A159, A164, A168, and A175.

Distribution: The collection of this species at Yakobi Island, Lisianski Strait (57°57′ N, 135°23′ W), Alaska, is farther north than Rathbun's (1918) record of Sitka, Alaska. The known southern limit is the Gulf of California, Mexico.

Hemigrapsus oregonensis (Dana, 1851)

257 specimens from the intertidal zone at stations A2, A7, A8, A15, A18, A25, A81, A83, A86, A87, A88, A91, A92, A96, A98, A99, A115, A136, A151, A159, A164, A174, and A175.

Distribution: The occurrence of this species in Resurrection Bay (60°0′ N, 149°17′ W) Alaska, is farther west than the previous record of Prince William Sound, Alaska (Rathbun 1918). The known southern record is the Gulf of California, Mexico at depths to 50 fathoms (Rathbun 1918).

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THE ZOOPLANKTON OF FIVE SMALL MOUNTAIN LAKES IN SOUTHWESTERN ALBERTA

By R. Stewart Anderson*

INTRODUCTION

Comparatively little basic limnological research has been carried out in the mountain lakes and ponds of southwestern Alberta, and accounts of many of these investigations remain unpublished. The majority of the recorded studies have been conducted in Banff and Jasper National Parks, and a summary of some of these is found in Frey (1963). The hydro-electric reservoirs on the Spray and Kananaskis Rivers west of Calgary have received some attention from Nursall (1952, 1960 unpub., 1961 unpub.), Fillion (1961 unpub.), and Fillion and Paterson (1962 unpub.).

This report is based on the preliminary studies of zooplankton communities in five of twelve small mountain lakes and ponds investigated in southwestern Alberta. The main collections were made during the summer seasons of 1965 and 1966, although additional collections were made at other times when weather and road conditions permitted. In view of the limited information available at this time, few ecological inferences have been made.

ACKNOWLEDGMENTS

This study was begun in 1965 with financial support from the National Museum of Canada and from the Biology Department of The University of Calgary. Further collections were made in 1966 in conjunction with Canadian Wildlife Service studies of high mountain lakes in the National Parks.

For making and confirming identifications, the author is indebted to Dr. E. L. Bousfield, National Museum, Dr. G. W. Comita, North Dakota State University, Dr. R. Hartland-Rowe and Dr. C. D. Bird, University of Calgary, Dr. D. R. Oliver, Canada Department of Agriculture, and Dr. E. B. Reed, Colorado State University. Water analyses were carried out by the Industrial Waters Section, Canada Department of Energy, Mines, and Resources. Thanks are also due to my wife, to personnel of the Canadian Wildlife Service and of the Alberta Department of Lands and Forests, and to Dr. P. K. Anderson and others who have helped on different occasions.

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THE WATERS

The waters discussed in this report are located in the high montane and subalpine zones of the Bow River and Crowsnest Forest Reserves of southwestern Alberta (Figure 1). Most of the waters are near the tree limit, but none is truly alpine. Two ponds are considered semi-permanent because they contain water throughout the spring, summer, and fall, but normally freeze to the bottom during winter. Contour maps are given in Figure 2. Figure 3 is a graphic summary of the duration of ice-cover, maximum-depth fluctuations, surface and bottom temperatures, and light penetration estimates.

The locations, elevations, and some physical features are included in Table I. A summary of August, 1966 water analyses is given in Table II. From this table, it can be seen that none of the five waters was unusual in terms of water chemistry, nor was any one very rich in nutrients.

TABLE I. Descriptive data for the five lakes

Water	Location	Elevation (metres)	Approx. area (hectares)	Approx. max. depth (metres)
Plateau Pond	50°14′N 114°30′W	2180	0.4	5
Teardrop Pond	50°12′N 114°27′W	2030	0.5	1.5
Bear Pond	51°13′N 114°26′W	1800	1.3	5
Rae Tarn	50°39′N 114°58′W	2180	4.5	3.5
Elbow Lake	50°38′N 115°00′W	2140	8	8

Physically and chemically, these lakes and ponds compared closely to many of the Colorado alpine and subalpine ponds (Pennak 1955*a*; Patalas 1964) and with the lakes and ponds of the Arctic Slope of northern Alaska (Reed 1962), although the lakes and ponds of Reed's study were considerably higher in chloride content than the Alberta or Colorado waters.

Plateau Pond (Plate I top) is located about 7 kilometres northwest of Teardrop Pond and is separated from it by 2,500 metre mountains. Plateau Pond was subject to large water-level fluctuations (Figure 3) although it has no surface outlet and no permanent inlet stream. Strong winds kept the water turbid during most of the open season. Mats of filamentous algae occurred on the bottom, but no rooted vegetation occurred. The shoreline vegetation consisted of scattered clumps of grasses. The bottom sediments contained very little organic matter. Oxygen saturation was found to be very high during the open season and was never less than 70 per cent even after 25 centimetres of ice had formed. After freezeup in late fall, the water remaining under the ice slowly drained out through the rock formation, leaving only about 40 centimetres of ice by December.

Teardrop Pond (Plate I, middle) is located at the summit of the Johnson Creek Pass west of the Willow Creek Ranger Station. Shallow and saucer-shaped, the pond had no surface outlet and no permanent inlet stream. Although the water level varied, it seldom exceeded 1.5 metres. The bottom sediments were largely

organic and were about two-thirds grown over with *Potamogeton* sp. and *Ranunculus* sp. Phytoplankton was found to be diverse but never very abundant. There was little shoreline vegetation. Because the Pass is subject to high and almost constant winds (occasionally to 190 kilometres per hour) the water was very turbid during most of the open season, and oxygen saturation was seldom below 100%. In exceptionally dry years, the pond may almost dry up in summer. It is not known whether the pond freezes to the bottom every year, although this is likely the case.

TABLE II. Summary of water analyses.
– samples from approx. mid-depth, August 1966.
– units in ppm except where otherwise noted.

	Plateau Pond	Teardrop Pond	Bear Pond	Rae Tarn	Elbow Lake
Specific conductance – u-mhos @ 25° C	160	83	52	206	322
Organic matter – 0_2 (as $KMnO_4$) consumed	2.4	3.8	5.3	1.2	1.2
Turbidity units	20	5.2	0.7	0.3	0.1
Hardness, total – $CaCO_3$ equiv.	81	43	26	107	166
pH, field	7.8	10.2	7.3	8.7	7.9
Alkalinity, total – $CaCO_3$ equiv.	74	39	25	85	99
Sulphates	9	3	3	23	67
Chlorides	0.6	0.3	0.3	0.2	0.4
Fluorides	0.06	0.12	0.08	0.06	0.52
Bicarbonate	90	37	30	103	121
Silica	1.0	0.4	0.5	3.0	2.1
Calcium	25	13	8	32	47
Sodium	0.2	0.1	0.9	1.0	0.4
Magnesium	4.7	3.0	1.2	6.8	12.0
Iron, total	0.27	0.21	0.42	0.04	0.04
Manganese, total	0.03	0.01	0.01	<0.005	0

Bear Pond (Plate I, bottom) is located about 3 kilometres northeast of Teardrop Pond. Dead trees along part of the shoreline were killed when the water level was raised about 2 metres by means of an earthen dam a few years ago. Bottom sediments were highly organic and rooted vegetation occurred over much of the bottom. A few sedge patches occurred along the shore. Although the pond is subject to almost constant wind, the water was usually transparent to a depth of 2 metres or more. Dissolved oxygen content during the open season was found to be high, but saturation near the bottom in December, 1966, (25 centimetres of ice) was only 8%. There is little doubt that severe oxygen depletion in winter is

the reason why attempts to establish trout populations in this pond have proved unsuccessful.

Bear Pond is the only water of those discussed in this report where an algal bloom was observed at a sampling time. Here, *Gloeotrichia* sp. reached bloom proportions in late August of both 1965 and 1966.

FIGURE 1. Bow River and Crowsnest Forests.

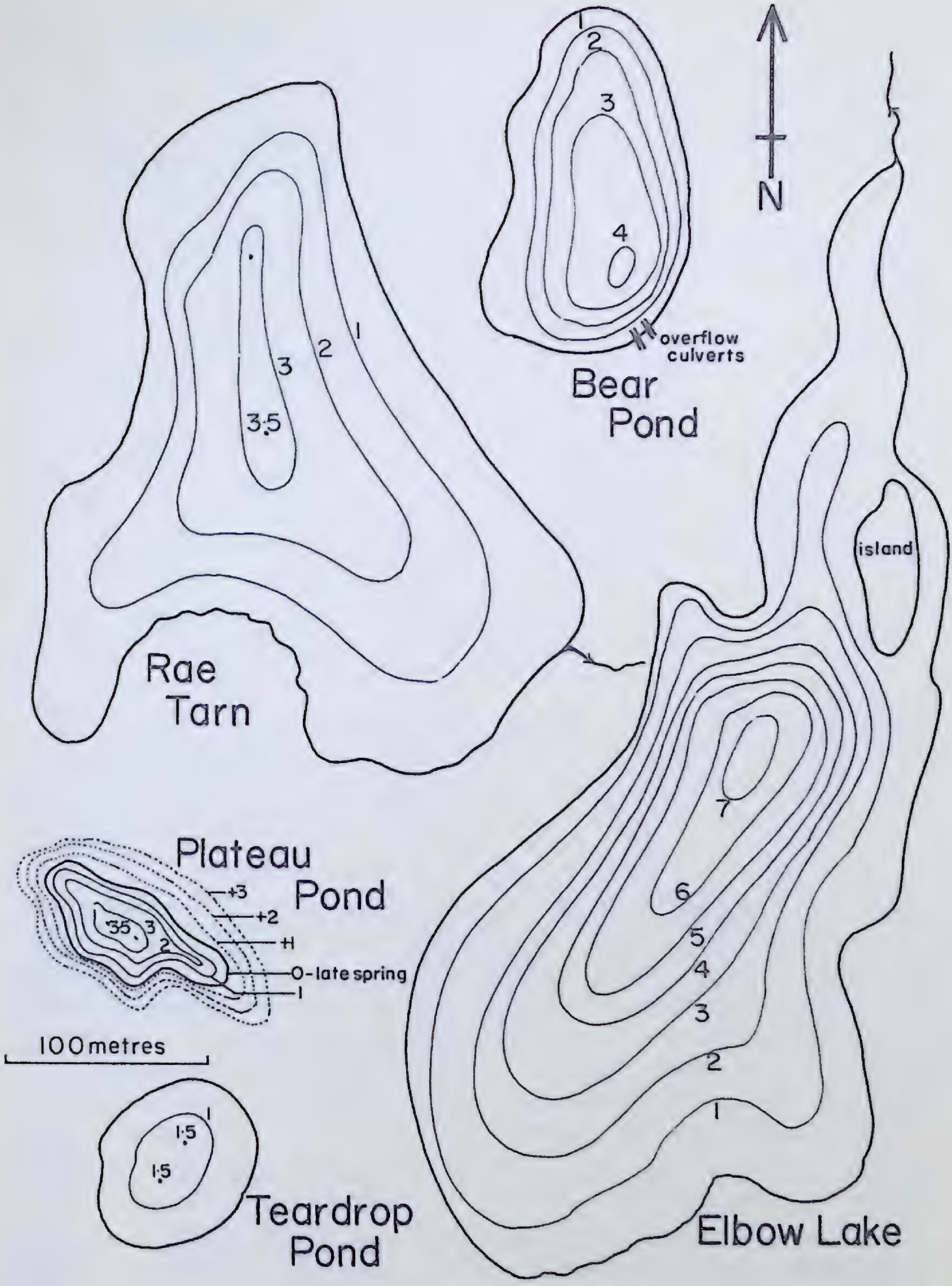

FIGURE 2. Contour maps of the five lakes.
Scale: 4 cm = 100 m.
Contours in metres.

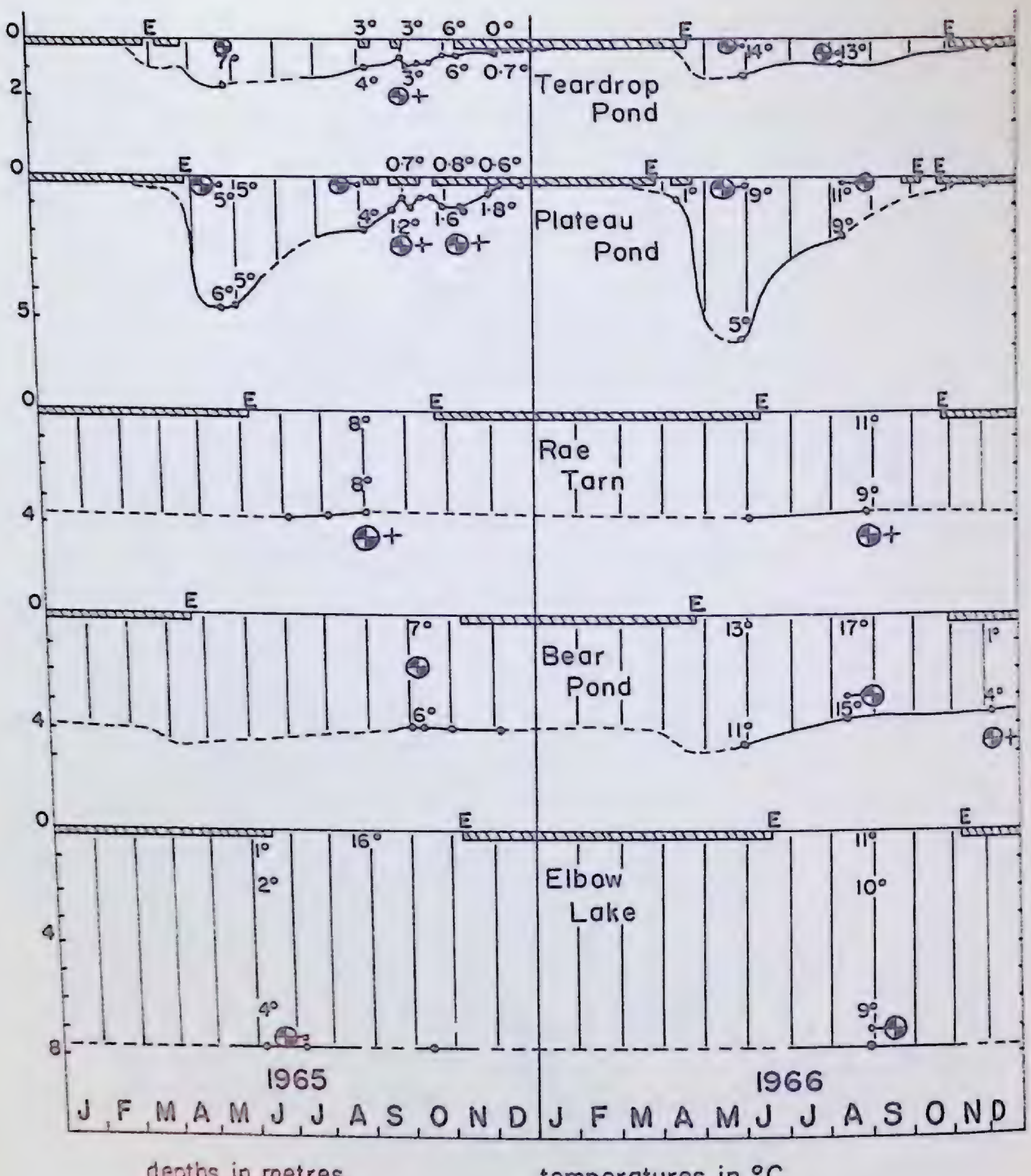

FIGURE 3. Maximum-depth variations, ice-cover durations, surface and bottom temperatures, and Secchi disc readings for the five lakes.

Rae Tarn (Plate II, top), about 80 kilometres northwest of Teardrop Pond, is situated near the north foot of Mt. Rae. Although the general vicinity is subject to considerable wind, Rae Tarn is sheltered from prevailing winds and the water was usually clear and calm. Net phytoplankton in the tarn was sparse, and only scattered rooted vegetation was found over most of the organic bottom sediments. A few sedge patches occurred along the shore. The Cougar Ponds, a chain of three

large, shallow ponds and a number of smaller ones, are located in a meadow about 2 kilometres east of Rae Tarn.

Elbow Lake (Plate II, bottom) is the largest of the waters discussed in this report and was the only one supporting a population of fish. Most of the shore was bordered by spruce forest, although sedge patches occurred at the north and south ends, and a meadow extends to the north of the lake. The bottom was variable, ranging from silt and organic sediments in some areas to patches of sand and gravel in others; some rocky areas were created by recent slides. Little of the bottom had much rooted vegetation, and net phytoplankton was sparse. Some winter-kill of fish has been claimed, but it is not certain whether oxygen depletion is ever severe. The studies conducted so far are not complete enough to warrant a more detailed description of this lake.

METHODS

Zooplankton was collected with a Wisconsin-type plankton net made of #20 bolting silk, usually from a rubber dingy. Phytoplankton was preserved in Transeau's preservative (Prescott 1962), and zooplankton in 10% formalin or 70% alcohol. Water analyses were done by the Industrial Waters Section, Department of Energy, Mines, and Resources.

The nomenclature in this report generally follows Ward and Whipple (Edmondson 1959). Identifications were made from Brooks (1957), Edmondson (1959), Pennak (1953), Prescott (1962), and Smith (1950), and by authorities whenever their services and advice could be obtained (see Acknowledgments).

The 1965 collection has been deposited at the National Museum of Canada. Representative chironomids have also been retained by the Entomology Research Institute, Canada Department of Agriculture.

THE ZOOPLANKTON COMMUNITIES

Although most of the species examined are typical zooplankton species, the use of the term "zooplankton" is perhaps questionable in a discussion of the communities of waters which are almost entirely littoral in zonation. However, as there appeared to be little change in the constitution of the plankton communities towards shore, no attempt has been made to separate littoral from limnetic species. Bottom samples were not taken, but some bottom organisms which occurred in net hauls are treated briefly. Table III summarizes the planktonic crustaceans taken in the five waters during 1965 and 1966, and Table IV is a list of the rotifers found in the community samples.

The crustacean zooplankters found in the two semi-permanent ponds, Teardrop and Plateau Ponds, are not characteristic of either temporary or permanent waters. Of all the waters in the study, Plateau Pond was the only one yielding fairy shrimp. *Branchinecta paludosa* was many times more abundant here in 1966 than in 1965. Two diaptomid copepods and one cyclopoid species were found in each of these two ponds. The occurrence of *Diaptomus victoriaensis* Reed 1958 in Plateau Pond is believed to be the fourth reported occurrence

of this species and the first outside the Arctic (Reed 1964a and personal communication). *D. tyrrelli*, found in Teardrop Pond, frequently occurs in permanent lakes in the nearby National Parks (Reed 1959 unpub.). *D. shoshone*, fairly common to alpine and subalpine lakes in Colorado (Reed and Olive 1958), occurred in both ponds. Nauplii were taken from both ponds in May, and copepods of all three species remained abundant until freezedown in both 1965 and 1966.

TABLE III. Planktonic crustaceans

	Plateau Pond	Teardrop Pond	Bear Pond	Rae Tarn	Elbow Lake
ANOSTRACA					
Branchinecta paludosa	x				
COPEPODA					
Diaptomus arapahoensis				x	x
D. shoshone	x	x			
D. victoriaensis	x				
D. leptopus			x		
D. tyrrelli		x			
Macrocyclops ater				x	
Cyclops vernalis	x				
C. thomasi		x	x	x	x
C. (?) varicans				x	
CLADOCERA					
Daphnia pulex	x	x		x	
D. schødleri			x		x
Simocephalus vetulus		x	x		
Alona guttata				x	
Chydorus sphaericus	x	x	x	x	x

TABLE IV. Rotifers

	Plateau Pond	Teardrop Pond	Bear Pond	Rae Tarn	Elbow Lake
Polyarthra sp.			x		x
Kellicottia longispina			x		
Keratella cochlearis	x	x	x	x	x
K. quadrata		x	x		x
K. hiemalis			x		
Asplanchna sp.			x		
Brachionus sp.	x	x			
Lecane (?) depressa					x
Synchaeta sp.			x		
Asplanchnopus sp.			x		
Unidentified rotifers			x		x

Cyclops vernalis, found in Plateau pond, frequently occurs in temporary ponds, whereas *C. thomasi,* found in Teardrop Pond, is often found in permanent lakes (Reed 1959). Cyclopoid adults were usually abundant only in the spring in these two ponds. *Chydorus sphaericus* was abundant in Teardrop Pond both years, and a single specimen occurred in a sample from Plateau Pond in 1966. *Daphnia pulex* was much more abundant in Plateau Pond in 1966 than in 1965. Both *D. pulex* and *Simocephalus vetulus* occurred in Teardrop Pond in 1965 in small numbers, but neither was taken in 1966.

Fairly dense populations of corixids and chironomids (*Psectrocladius* n. sp.) in Plateau Pond in 1965 appeared to survive the winter on the frozen lake bottom with a fairly low mortality. A number of these chironomids, which normally inhabit gelatinous coccoons lying on the surface of the bottom sediments, were kept frozen at −20°C for three months and were found to resume normal activity within three days of the beginning of melting at temperatures of about 1°C. The ability to survive under similar conditions has been reported before for certain chironomids (Borodicova 1957; Fillion 1963). Chironomids were less abundant in Teardrop Pond, although three genera were found *(Cricotopus* sp., *Cryptochironomus* sp., *Procladius* sp.).

Diaptomus leptopus was the only diaptomid copepod found to occur in Bear Pond. *Daphnia schϕdleri* and *Simocephalus vetulus* both occurred in samples in 1965, but *S. vetulus* was not found in the 1966 samples. Immature cyclopoid copepods were abundant in May, less numerous in August, and rare in December. Adult *Cyclops thomasi* were numerous early in the year and again in October. It is likely that all cyclopoids were the same species. *Gammarus l. lacustris, Hyalella azteca,* corixids, chironomid larvae, and various nymphs and naiads commonly occurred in samples. *Chaoborus* sp. larvae were frequently abundant.

In both 1965 and 1966, the patterns of development and abundance of the most numerous zooplankters, *Diaptomus leptopus* and *Daphnia schϕdleri* differed somewhat from those reported for the same species by Hazelwood and Parker (1963) and Healey (1967). In Bear Pond, no *D. schϕdleri* were taken in May, June, or December. In August, parthenogenetic females and immature daphnids were abundant, and an occasional ephippial female was taken. In October, ephippial females were abundant, a few parthenogenetic females were taken, and juveniles were still fairly numerous. *Diaptomus leptopus* numbers were fairly high in May, very high in August through October, and somewhat reduced in numbers by December. Egg-bearing females were common in December and very abundant in early May. Copepodids appeared to reach their peak of abundance in the period mid-July to mid-August. The population maximum for *Daphnia schϕdleri* appeared to occur about the same time or possibly later by as much as two weeks. Whether competition occurs between these two species can only be determined by detailed studies along the lines of those conducted by Hazelwood and Parker. It would be enlightening to study the relationship of *Cyclops thomasi* and *Chaoborus* sp., also abundant in the pond, to the patterns of development of the other two species.

In Rae Tarn, although total zooplankton numbers were the lowest of any of the five waters, July samples yielded abundant *Diaptomus arapahoensis* in both 1965 and 1966 and no *Daphnia pulex*. August samples both years yielded abundant *D. pulex*, no diaptomids in 1966, and very few in 1965. Cyclopoid copepods were most abundant in Rae Tarn later in the season, somewhat opposite to the case in Teardrop and Plateau Ponds. Chironomids were sparse, but three genera were taken (*Cricotopus* sp., *Tanytarsus* sp., *Corynoneura* sp.). *Gammarus l. lacustris* was abundant at every visit, and a limited number of nymphs and naiads were noted.

D. arapahoensis appeared to develop later and in greater numbers in Elbow Lake than in Rae Tarn. *Daphnia schødleri*, the only abundant cladoceran plankter in Elbow Lake, occurred at about the same time. No insects were taken in plankton tows in this lake in either 1965 or 1966, probably a reflection on the feeding efficiency of the population of *Salvelinus fontinalis* present in the lake.

DISCUSSION

The absence of many common species in some of several lakes in close proximity and peculiar patterns of occurrence and co-occurrence in different lakes suggest that dispersion is random and incomplete, probably because specific barriers to dispersal exist, and because fairly definite niche requirements must be met before survival can occur.

In only two cases did the same diaptomid species occur in more than one pond: *Diaptomus shoshone* in Plateau and Teardrop Ponds, and *D. arapahoensis* in Elbow Lake and Rae Tarn. These pairs of waters were only relatively close and were separated by 2,500 metre and 2,900 metre mountains respectively. It is notable that the first two ponds were both semi-permanent, whereas the latter two waters were permanent. *Daphnia pulex* from Plateau and Teardrop Ponds appear to be of the same race, but *D. pulex* from Rae Tarn and Cougar Pond (2 kilometres apart) appear to be a distinct race showing both *schødleri* and *middendorffiana* characteristics. *Simocephalus vetulus* occurred in both Teardrop and Bear Ponds (3 kilometres apart), whereas *D. schødleri* occurred only in Bear Pond and Elbow Lake (about 80 kilometres apart).

In this study, as shown elsewhere (Goulden 1964; Reed 1962), *Chydorus sphaericus* appears to be the most cosmopolitan of the cladocerans. *Keratella cochlearis*, the most frequently occurring rotifer, is usually considered cosmopolitan also (Dussart 1956; Pennak 1955a, 1957). The erratic occurrence of some cladocerans, such as *Alona guttata* (Rae Tarn 1966, but not 1965), *Simocephalus vetulus* (both Bear and Teardrop Ponds 1965, but not 1966), *Daphnia pulex* (Teardrop Pond 1965, but not 1966), and *Chydorus sphaericus* (Plateau Pond 1966, but not 1965) suggests that either sampling was insufficiently thorough, or that the numbers in a given lake may be drastically reduced in years when conditions are not particularly suitable (Dussart 1956). An explanation of

distribution is obviously not simple, and the need for more frequent sampling and the inclusion of additional lakes is clear.

Although accurate quantitative counts were not made, estimates of population densities and numbers of dominant crustacean species conform to the general conclusions of Patalas (1964) and Reed (1964b). They note that alpine and high montane lakes usually have only 2 or 3 dominants (i.e. crustacean species comprising over 10% of the total number of crustaceans) at any one time and that one species is usually a copepod and one a cladoceran. In two instances (Plateau and Teardrop Ponds) where two dominants were both diaptomids, the larger species *(D. shoshone* in both cases) was observed to feed on the smaller species. This observation is in disagreement with the niche assignment given *D. shoshone* by Pennak (1955*b*).

Pennak (1955*a*) noted that the cladoceran faunae of mountain lakes are usually more varied than the copepod faunae of the respective lakes. In this study, the maximum and minimum numbers of copepod species per lake were 4 and 2 with a mean of 2.8. The maximum and minimum numbers of cladoceran species were 3 and 2 with a mean of 2.6. The total number of copepod species (9) was about twice the total number of cladoceran species (5), and the number of copepod species per lake was about the same as the number of cladoceran species. Sampling during all seasons and in a larger number of lakes could conceivably alter these ratios.

Goulden (1964, also citing Lang 1931) remarks that cladocerans are usually succeeded by copepods which give way to rotifers as eutrophication proceeds. Although the number of permanent lakes considered here is not large enough to be treated statistically, Tables III and IV do show that the lakes (Bear Pond and Elbow Lake) having the largest number of rotifer species also have the smallest number of copepod and cladoceran species. Bear Pond is certainly among the most eutrophic of the lakes studied, but Elbow Lake does not appear to be as eutrophic as Teardrop Pond or Rae Tarn, samples from which indicated sparse rotiferan faunae.

Brooks and Dodson (1965) and Galbraith (1967) have indicated that fish predation may have a definite effect on the composition of the zooplankton in a given lake. Brooks and Dodson found that some larger species may be eliminated, to be replaced by smaller species. Galbraith found that zooplankton below a certain size (about 1.3 mm) was of little importance in the diet of *Salmo gairdneri.* Although Macan (1966) found that plankton was not significant as food for *Salmo trutta,* Keast (1965, 1966) and Keast and Webb (1966) found that zooplankters, including very small species, may make up a significant part of the diets of some small fish species and also of larger species during their early life.

A consideration of the sizes of crustacean zooplankters found in the five lakes in this study (Table V) indicates that the presence of a fish population may have a bearing on the sizes and species present in a lake. Elbow Lake was the only

one of the five not having a large daphnid (over 2 millimetres), and only the smallest size-range of calanoid and cyclopoid copepods occurred here. These data tend to lend some support to the contention that zooplankters below 1.3 millimetres are not actively sought as food by trout.

TABLE V. *Sizes* of mature, adult crustaceans among the dominant and subdominant zooplankters in the five lakes.***

	Cyclopoids	Calanoids	Chydorids	Daphnids	Anostracans
Plateau Pond	1.3 – 1.4	A^{m}_{f} 2.4 – 3.0 / 2.5 – 3.2 B^{m}_{f} 3.2 – 4.0 / 3.8 – 4.4		2.1 – 2.3	20 – 25
Teardrop Pond		A^{m}_{f} 1.0 – 1.4 / 1.0 – 1.6 B^{m}_{f} 2.7 – 2.8 / 2.7 – 3.3	0.5	A 2.0 B 2.2	
Bear Pond	0.8	m 2.0 f 2.1 – 2.3	0.5	A 1.8 B 1.3 – 2.0	
Rae Tarn	A 1.0 – 1.1 B 1.8	1.4	A 0.5 B 0.3	2.4 – 2.9	
Elbow Lake	0.9 – 1.1	1.0 – 1.4	0.65	1.0 – 1.2	

* Sizes in mm
** m,f: male, female
A,B: first and second species

If this minimum size is a factor in trout predation, then two other points emerge from Table V. Adult *Chydorus sphaericus* in Elbow Lake were the largest of those occurring in any of the five waters. It is conceivable that reduced competition permits these animals to attain a greater size. Mature *Daphnia schödleri*, on the other hand, were smaller here (1.0 to 1.2 millimetres) than in Bear Pond (1.3 to 2.0 millimetres) and may reflect the effects of selection for survival against fish predation. These points are worthy of further investigation.

CONCLUDING REMARKS

This study lends support to the idea that a number of similarities exist between arctic and alpine aquatic environments. Nine of 15 species in Table III also occur in the species lists of Reed's (1964a) arctic study. Ten of 15 species in Table III occur in the alpine and subalpine species lists of Reed and Olive's (1958) study of Colorado mountain lakes. Seven of the 15 species in Table III are common to both of the other two studies. It is possible that a survey of Alberta lakes at higher elevations would reveal an even greater similarity.

Although the number of lakes considered here is small, the total number of species of crustacean zooplankters (15) collected in 5 lakes in this study compares favorably with the 47 species collected in 98 lakes by Reed and Olive (1958) in Colorado. Further studies in the Bow River and Crowsnest regions would be of value in adding to the information available on community associations and distributional patterns. Collections should be made from the high lakes and ponds at the headwaters of the Highwood and Oldman Rivers and the Kananaskis Lakes region (Figure 1). Field studies of niche requirements and specificity are important as a means to a more complete understanding of community associations. However, correlated laboratory and field studies are needed to clarify inter – and intra-specific relationships.

SUMMARY

1. The invertebrate communities and general limnology of 5 high montane and sub-alpine lakes and ponds in the Bow River and Crowsnest Forest Reserves of Alberta were examined.
2. Fifteen planktonic crustacean species were encountered, of which 9 were copepods, 5 were cladocerans, and one was anostracan.
3. The maximum and minimum numbers of copepod species per lake were 4 and 2 with a mean of 2.8. The maximum and minimum numbers of cladoceran species were 3 and 2, with a mean of 2.6.
4. The occurrence of *Diaptomus victoriaensis* is a new record for Alberta and is the fourth known recorded occurrence of the species.
5. The absence of many common species in some of several lakes in close proximity and peculiar patterns of occurrence and co-occurrence in different lakes suggest that dispersion is random and incomplete, probably because specific barriers to dispersal exist and because fairly definite niche requirements must be met before survival can occur.
6. Suggestions for further studies in the area were made.

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PLATE I

(top): Plateau Pond (2,180 m), late April, 1965

(middle): Teardrop Pond (2,030 m), mid-December, 1966

(bottom): Bear Pond (1,800 m), mid-December, 1966

PLATE I

PLATE II

(top): Rae Tarn (2,180 m), late August, 1966.

(bottom): Elbow Lake (2,140 m), early June, 1965.

PLATE II

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ERRATA and ADDENDA

p. 5 scale - should be 2.7 cm to 100 m (due to reduction)
p. 7 the fairy shrimp Eubranchipus intricatus (Hartland-Rowe 1967) was found in Teardrop Pond in 1967.

p. 13-15 (a) Archives Hydrobiology should be Archiv fur Hydrobiologie

(b) Verhandlungen Internationalen Vereins Limnologie should be Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie

(c) Limnological Oceanography should be Limnology and Oceanography

(d) Transactions American Microscopic Society should be Transactions of the American Microscopical Society.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

NEW RECORDS OF GAMMARIDEAN AMPHIPOD CRUSTACEANS FROM THE INTERTIDAL ZONE OF PRINCE WILLIAM SOUND, ALASKA

E. L. Bousfield

and

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Department of the Secretary of State

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NEW RECORDS OF GAMMARIDEAN AMPHIPOD CRUSTACEANS FROM THE INTERTIDAL ZONE OF PRINCE WILLIAM SOUND, ALASKA

By E. L. Bousfield and Joel D. Hubbard*

During the summer of 1965 the junior author conducted an ecological survey of intertidal invertebrates at Olsen Bay (60°45′30″ N, 146°11′ W), Prince William Sound, Alaska. A number of crustacean specimens, primarily amphipods, were obtained at the principal study area, a large tidal flat occupying the entire width of the bay head and transected along either side by the outwash flow of two streams. It is continuous with steep sand – coarse gravel – shingle beaches which extend around the entire perimeter of this small bay. Substrate of the tidal flat grades from silt-gravel in the upper and mid-tidal zones to pure mud below the +3.0-foot tide level. Olsen Creek, which flows along the northwest side of the tide flat, is by far the more important of the two streams both in terms of discharge and in supporting a substantial run of pink and chum salmon. The bulk of the amphipod specimens were taken from this stream. The stream-bed is composed chiefly of coarse well-washed gravels and cobble in the upper portions of the intertidal zone with increasing amounts of fine to coarse sediments, detrital material, and mollusc shell debris below the +5.0-foot tide level. Vegetation is extremely sparse, limited primarily to a brownish gelatinous alga closely adherent to the coarse substrate materials, chiefly in the upper intertidal regions. Mean stream temperatures from June to September were in the range of 4.5° to 10°C.

The amphipods comprise an important segment of the total fauna of Olsen Bay. Representative material was sent to the senior author for assistance in determining the species. Seven gammaridean amphipod species have been identified, mostly new to the Prince William Sound region. Of these, *Micruropus alaskensis* is newly described here and is the first N. American record of this Lake Baikal endemic genus, and *Paramoera carlottensis* Bousfield is recorded for the second time from the American Pacific coast.

Relatively little previous information is available on the intertidal environment or the amphipod fauna of the Prince William Sound region. The Olsen Bay area has been uplifted some four to five feet as a result of the Alaskan earthquake of 1964, thus accounting for much of the large expanse of pure mud exposed at the head of the bay at low tide. Distributional relationships of the intertidal invertebrate populations are currently being described (Hubbard, in prep.). Some pre-quake information on this general region is available from the U.S Fish and Wildlife Service at Auke Bay, Alaska, and from the station list of the National Museum Expedition to Prince William Sound and southeastern Alaska in 1961 (Bousfield and McAllister 1962). In early July, surface temperatures are moderately

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high for this latitude, about 13.5°C, and about 12° to 14°C over the tidal flat at Olsen Bay. At the same time, salinities are rather brackish (17–21.6‰), and water transparency is low because of turbulent river discharge from surrounding drainage basins. The fauna is essentially estuarine and boreal-subarctic in composition, but it contains extreme northern populations of some 'warm-water' southerly forms such as *Hemigrapsus oregonensis* and *Lophopanopeus bellus* (Hart, in prep.), *Upogebia pugettensis,* and the molluscs *Nassarius mendicus, Melibe leonina,* and *Crassostrea gigas* (introduced populations).

Previous regional records of amphipods are limited to those of the Harriman Alaska Expedition (Holmes 1904) and a few monographic studies on American-Pacific species that bracket the Prince William Sound area (e.g., Shoemaker 1947, 1955). Amphipods (including caprellids) of the 1961 National Museum of Canada Expedition to this region are being included in a series of monographs on families of Canadian-Alaskan shallow-water amphipods (for example, Mills 1962). The present study is intended to stimulate further investigations on the crustaceans of this faunistically rich and virtually unexplored region.

Specimens were taken from four localities as follows: Olsen Creek (SB stations); tide flat transect (OC stations); and two beach transects on the east shoreline near the bay head (EB 1 and EB 2 stations). Numbers following the SB stations, preceding the slash in OC stations and following the slash in EB 2 stations, indicate the tidal level in feet above mean low water (0.0 feet) at which the specimens were collected. EB 1 station elevations are listed individually.

Acknowledgment is made to the U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries Biological Laboratory, Auke Bay, Alaska, for their generous support of the field work.

SYNOPSIS OF THE SPECIES

Family PONTOGENEIIDAE

1. *Paramoera carlottensis* Bousfield 1958

Material examined. 414 specimens, stations SB 1–6, mouth of Olsen Creek, August 1965.

These specimens were significantly smaller (5–6 mm vs. 7–8 mm) than the type lots originally described from tide pools along the outer coast of the Queen Charlotte Islands, British Columbia. The material contained mostly immature specimens; one male with calceolate antenna 2 was noted (Station SB 5), but none of the females was ovigerous, and none had fully developed brood lamellae.

The present records extend the range of the species considerably northwestward. The relative abundance of the species in Prince William Sound suggests that this oligohaline brackish-water species is endemic to Alaskan coastal waters, reaching its southern limit in British Columbia.

2. *Paramoera columbiana* Bousfield 1958

Material examined. 100 specimens, stations SB 1–6, mouth of Olsen Creek, August 1965, and at EB 1/17 (+5.7-foot level) July 1965.

Although most of the specimens were subadult, a few large ovigerous females were noted (SB 5).

This species occurs commonly in stream mouths and tidal spray pools throughout the coast of British Columbia. Its relatively low abundance at present localities suggests that Prince William Sound may be near the northern limit of its range.

Family GAMMARIDAE

3. *Gammarus setosus* Dementieva

Material examined. 44 specimens, Stations EB 1/9, 1/15, 1/16, 1/18 (+4.8 to +6.0 foot levels), and OC 5.5/54, 5.5/88, and 5.5/92 (July 1965).

The eleven female specimens were non-ovigerous.

G. setosus has previously been recorded (as *G. locusta*) from the west coast of North America at Glacier Bay, southeastern Alaska, (Holmes 1904) and at Point Barrow, Alaska (Shoemaker 1955), well bracketing the present records. The eastern Pacific material differs from eastern Canadian subarctic and Atlantic material (e.g., Dunbar 1954) in being less setose on antennal peduncular segments and on the posterior margins of abdominal side plates. In some characteristics this Pacific variant seems intermediate between typical North Atlantic material of *G. setosus* and *G. oceanicus* Segerstrale.

4. *Anisogammarus confervicolus* Stimpson

Material examined. 688 specimens at nine stations, almost all at Stations SB 1–7, August 1965, and a few at Stations OC 2.5/83 and OC 5.5/54, July 1965.

This species is probably the most abundant estuarine and brackish-water amphipod in coastal waters from Alaska to California. The species is usually dominant on intertidal flats, particularly in the outflow of fresh-water streams, and is very common in tidal fresh waters of British Columbia (Bousfield 1958).

5. *Anisogammarus locustoides* Brandt

Material examined. 28 specimens at Stations EB 1/7, 1/15 (+10.0 and +5.2-foot levels, July 1965), EB 2/7, 2/7.5, 2/9, 2/9.5, 2/10, August 1965.

All specimens were subadult. Specimens conform essentially to the description and figures of Bousfield (1958).

The species ranges from eastern Siberia and Kamchatka, to central British Columbia. It frequently occurs with *A. confervicolus* at localities in British Columbia. At present stations it occurred only with *G. setosus* and in only one lot.

6. *Micruropus alaskensis* n.sp. (Figs. 1, 2).

Diagnosis. An aberrant marine species, provisionally placed in the genus *Micruropus,* characterized by a small, round, weakly pigmented eye; sparsely setose and spinose peraeopods and uropods; short, broad, powerful pleopods; and dorsally setose urosome. Segment 4 of peraeopod 2 is shortened and sharply arched anteriorly.

Material examined. Olsen Bay, Prince William Sound, Alaska, Station SB 5, Olsen Creek, intertidal. August 20, 1965, J. D. Hubbard coll. Male (HOLOTYPE),

Female (ALLOTYPE) and slide mounts, NMC No. 5764. Ibid. Male, female (PARATYPES), NMC No. 5765 and USNM collections.

Description. Male (7.0 mm). Body short, deep, talitroid, urosome abbreviated, upper surfaces of body and terminal appendages coated with short stiff pilosity. Head shallow, antennal angle subacute, inferior antennal sinus moderately incised. Eye small, round, with a few weakly pigmented facets. Antennae short, peduncles subequal, upper surfaces minutely pilose. Antenna 1, peduncular segments moderately stout, 2 and 3 subequal; posterior margins with 2 or 3 subterminal clusters of short setae; flagellum slender, longer than peduncle, 16-segmented; accessory flagellum minutely 2-segmented. Antenna 2 much shorter than antenna 1: peduncular segments 4 and 5 subequal, not expanded, 2 or 3 groups of posterior marginal setae; gland cone short; flagellum 10-segmented, shorter than peduncle, calceoli apparently lacking.

Upper lip heart-shaped, apically pilose; epistome a little produced anteriorly. Lower lip broad, lacking definitive inner lobes. Mandibles with well developed molar process; incisor with four teeth; lacinia 3 or 4 cuspate; left mandible with one spine-like accessory blade; right mandible with 4 plumose accessory blades. Palp strong, segment 2 longest, with inner distal tuft of slender spines; terminal segment with inner distal row of short stout pectinate setae and 3 or 4 long slender apical setae. Maxilla 1, inner plate with 9 plumose marginal setae; outer plate with 9 pectinate spine-teeth on truncate apex; palp 2-segmented, apically short-spinose. Maxilla 2, plates subequal, inner plate with facial row of 10 strong setae. Maxilliped, plates elongate; inner plate with 3 stout apical spine-teeth and 5 or 6 inner marginal plumose setae; outer plate exceeding inner, rounded apex lined with slender curved spines; palp strong, segment 2 longest; dactyl long, curved, slender; segment 3 with several long slender pectinate apical spines.

Gnathopod 1, lower margin of coxal plate lined with several weak spines and setae. Segment 2 arched, margins strongly setose. Segment 2 with short setose lobe produced between segment 4 and 6 and inner distal margin bearing a row of long pectinate spines; segment 6 subquadrate, posterior margin weakly setose, palmar margin nearly vertical, lined with stout peg-like spines. Dactyl stout, short, strongly curved. Gnathopods 1 and 2 roughly similar in shape and size; segment 6 slightly larger in gnathopod 1.

Gnathopod 2, anterior margin of segment 2 weakly setose; segment 6 narrower than in gnathopod 1, palmar margin oblique with peg-teeth concentrated at palmar angle, posterior margin with three distal groups of strong setae; dactyl as in Gnathopod 1, nail stout.

Peraeopod 1 a little longer than peraeopod 2, coxal plate narrower with weak marginal setae; segments moderately strong, lightly setose; dactyl short. Peraeopod 2, coxal plate nearly as broad as deep, rounding below, with 3 or 4 long postero-ventral setae, posterior marginal shallowly incised; segment 4 shortened, strongly arched anteriorly, margin with a few stiff setae; segment 6 slender; dactyl short, nearly straight.

Peraeopods 3–5 successively longer; coxal plates shallow, short; dactyls held in reverse position; posterior margins of segment 2 lightly setose; segments

4 and 5 moderately stout, lightly spinose. In peraeopod 5, basos (segment 2) strongly expanded posteriorly, margin broadly rounding. Coxal gills moderately large, sac-like, pedunculate, attached to coxae 2–6. No accessory gills observed.

Pleopods short, stout, powerful, outer ramus 7 and 8 segmented, longer than inner ramus; peduncles broad, stout, outer margins plumose, inner margin with 2 elongate coupling spines. Abdominal side plates 1–3 obtuse-angled, posterior margins distally with short setae. Urosome segments short and deep, slightly humped dorsally; segments 1 and 2 with paired slender setae middorsally. Uropod 1 exceeding uropod 3 and telson; peduncle longer than subequal rami with few lateral spines; interramal spine prominent. Uropod 2 similar, shorter. Inner ramus of both uropods 1 and 2 with single midmarginal spine. Uropod 3 short, peduncle stout, longer than rami; outer ramus one-segmented, with 4 or 5 slender terminal spines; inner ramus very short, conical, with single terminal seta. Telson broad, deep, bilobed, cleft nearly to base; rounded apices with a few short spines; dorsal surface finely pilose.

Description. Female (6.0 mm). Slightly smaller than male. Antennae similar to male. Gnathopods 1 and 2 less powerful than in male; segment 6 of gnathopod 2 smaller, more slender than in gnathopod 1; palmar margins with fewer peg-teeth. Brood plates little expanded, length about equal to respective leg segment 2, margins with a few long simple setae. Brood pouch carries 4 or 5 eggs (diameter 0.35 mm).

Remarks. Except for the presence of a minutely two-jointed (rather than one-jointed) accessory flagellum, the present species conforms well with the generic description of *Micruropus* given by Bazikalova (1945) and Gurjanova (1951). Using Bazikalova's keys (p. 25, 36), the Alaskan species approaches most closely the subgenus *Setogammarus* Baz. and the species *ciliodorsalis* Sow. In this subgenus, the body is covered with short hairs; the abdominal side plates are posterior setose; the eyes are small and round; the basipodite of peraeopod 5 is broadly oval or subquadrate; and the outer ramus of uropod 3 is one-segmented. However, the present species differs in having short, rather than long slender marginal spines on uropods 1 and 2, having relatively few short hairs rather than numerous long setae on the posterior margin of peraeopod 5 basos, and having a telson not completely cleft to the base. The mouthparts (especially mandible and maxilla 1) of *M. alaskensis* more closely resemble those of the subgenus *Micruropus* Stebb., than those of the subgenus *Setogammarus* Baz., as illustrated by Bazikalova (1945; plate 2). On the basis of its observed differences and peculiar characteristics, the present species might justify new subgeneric (and perhaps generic) recognition. The writers have seen no material of the 32 species and subspecies of this Lake Baikal endemic genus. Until these taxons have been more completely defined to include full descriptions of important characteristics such as branchiae, brood plates, and pleopods, the Alaskan species is provisionally placed in the genus *Micruropus* Stebb. (sens. lat.). If such action proves valid, *Micruropus alaskensis* becomes the first record of the genus outside Lake Baikal, the first outside eastern Asia, and the first from a marine-brackish habitat. Until further distributional records come to hand, the phylogenetic and zoogeographical affinities of the entire group are problematical and speculative.

The peraeopods and short stout pleopods appear to be fossorial in type (cf., *Pontoporeia*, Dogielinotidae) suggesting that the species burrows or tunnels in the substratum.

The abbreviated urosome of *M. alaskensis* imparts a superficially talitroid appearance to this animal. Presumably on this account Dybowsky had applied the specific name "talitroides" to a complex of subspecies of the subgenus *Micruropus*. The gammaroid genus *Hyalellopsis* Sow., also endemic to Lake Baikal, bears a remarkable superficial resemblance to the talitroid genus *Hyalella*, having in common an abbreviated urosome, small uniramous third uropod, and entire telson. Such instances of convergent evolution complicate the problem of establishing the origin, evolution, and phylogeny within the primitive family Gammaridae, and indeed within the entire crustacean order Amphipoda.

Family Corophiidae

7. *Corophium spinicorne* Stimpson

Two specimens of this large species were collected; a male at EB 1/8 (+4.6-foot level), July 1965, and an ovigerous female at EB 2/2.5, August, 1965.

A common species of tidal fresh waters and estuarine mud flats, from Amchitka Island, Alaska to southern California (Shoemaker 1949; Bousfield 1958).

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ABBREVIATIONS FOR FIGURES

A1	Antenna 1	Mxpd	Maxilliped
A2	Antenna 2	Gn1	Gnathopod 1
Hd	Head	Gn2	Gnathopod 2
UL	Upper Lip	P 1–5	Peraeopods 1–5
LL	Lower Lip	Ep 1–3	Abdominal side plates 1–3
Rt. Md.	Right Mandible	Pl 1–3	Pleopods 1–3
Lft. Md.	Left Mandible	U 1–3	Uropods 1–3
Mx1	Maxilla 1	T	Telson
Mx2	Maxilla 2	UR	Urosome

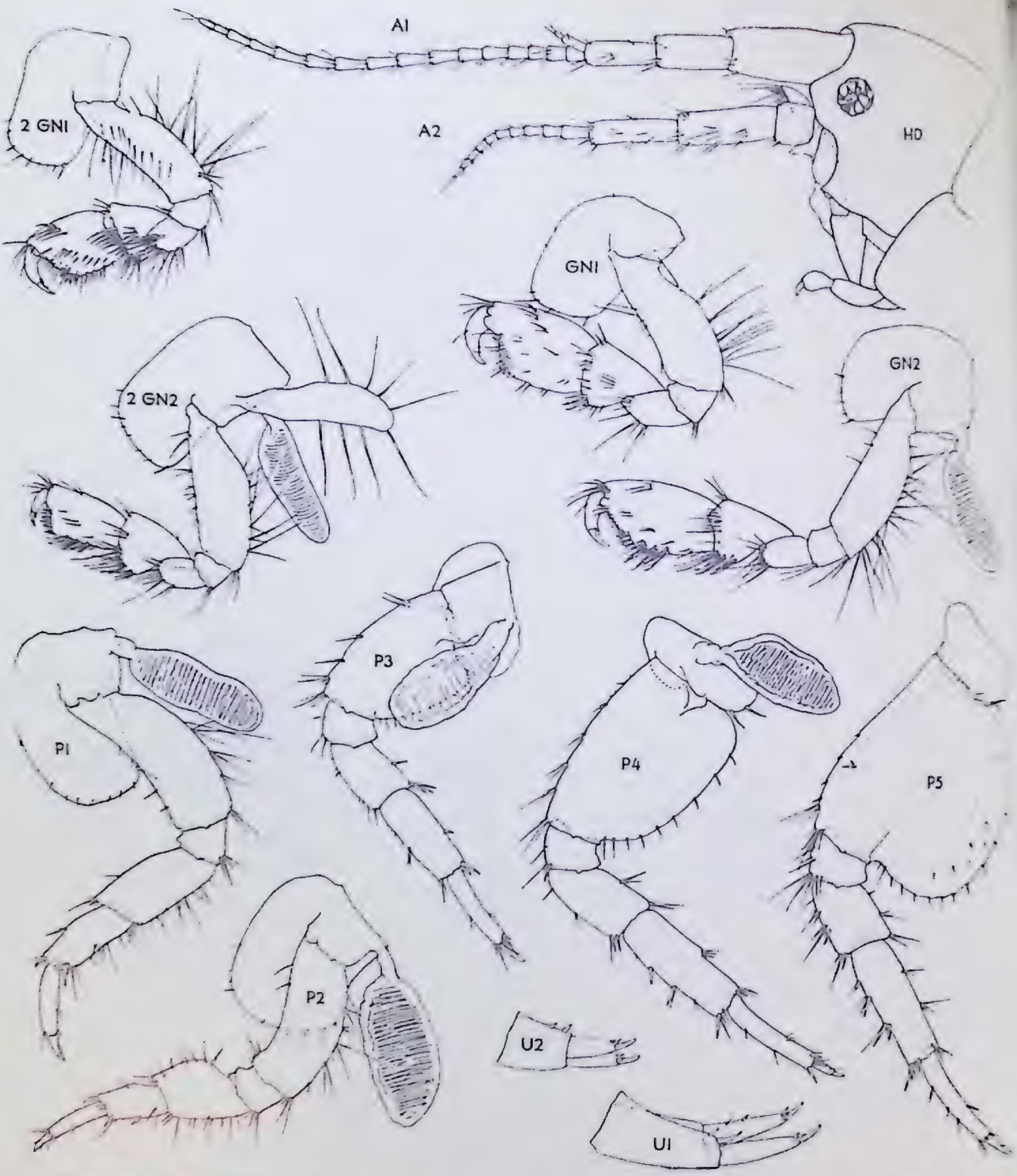

FIGURE 1. *Micruropus alaskensis* n.sp. from Olsen Bay, Alaska. 1. Male (Holotype) 7.0 mm. 2. Female (Holotype) 6.0 mm.

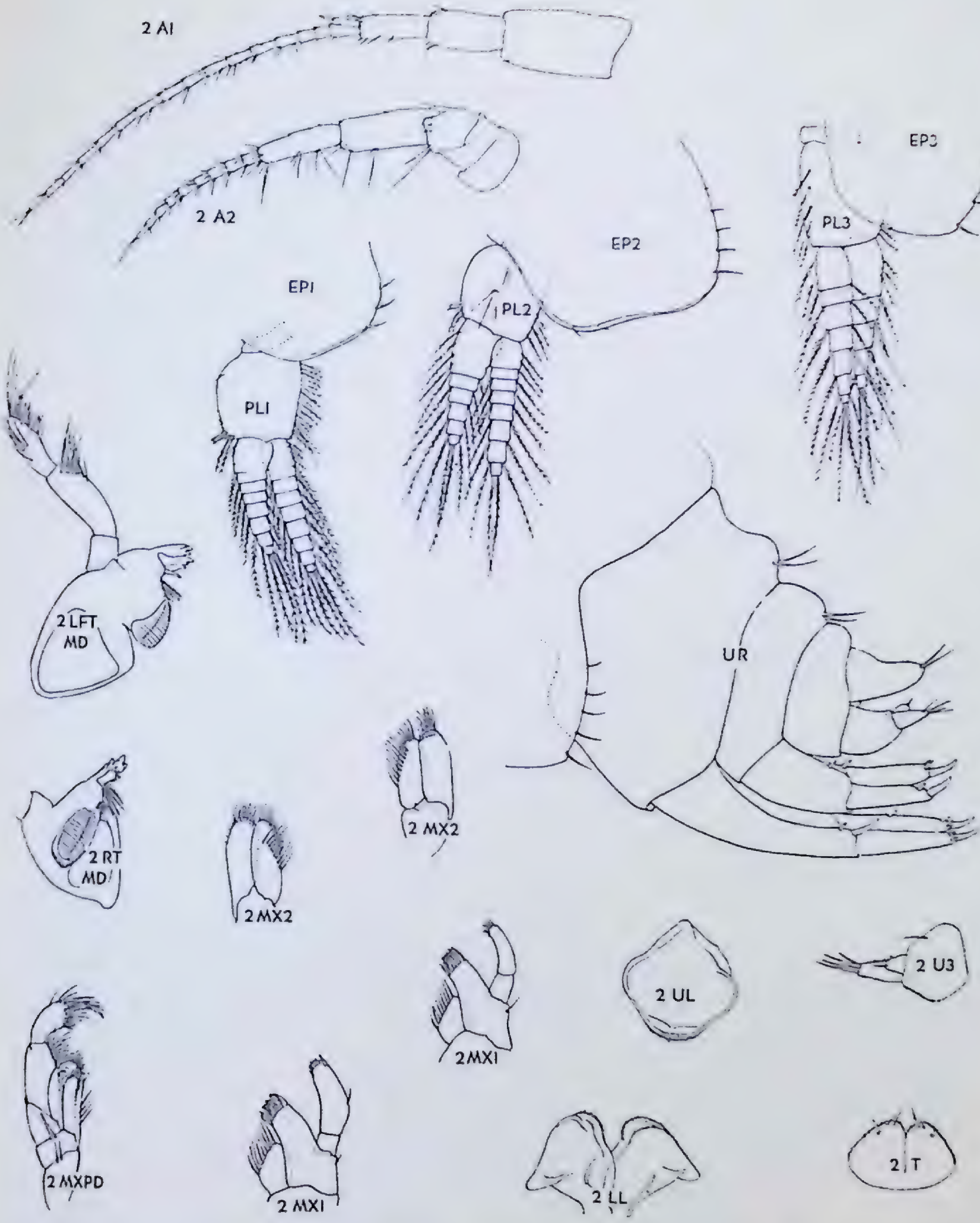

FIGURE 2. *Micruropus alaskensis* n.sp. from Olsen Bay, Alaska. 1. Male (Holotype) 7.0 mm. 2. Female (Holotype) 6.0 mm.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

CRAYFISH IN THE VICINITY OF LONDON, ONTARIO

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CRAYFISH IN THE VICINITY OF LONDON, ONTARIO

W.W. JUDD

During the summer of 1965, the distribution of crayfish in the vicinity of London, Ontario, was studied as part of the program of studies of non-insect invertebrates sponsored by the National Museum of Canada. A previous brief account of the occurrence of *Cambarus fodiens* near London is given by Judd (1955) and also of *Cambarus bartoni robustus* and *Orconectes propinquus* (1957).

From May 15 to August 31, crayfish were sought at seventy sites (A1 – Z1, A2 – Z2, A3 – R3) within twenty miles of the city of London (Figure 1). A map of the area was traced from the Lucan and St. Thomas sheets of the National Topographic series. The North Branch and the South Branch of the Thames River meet in

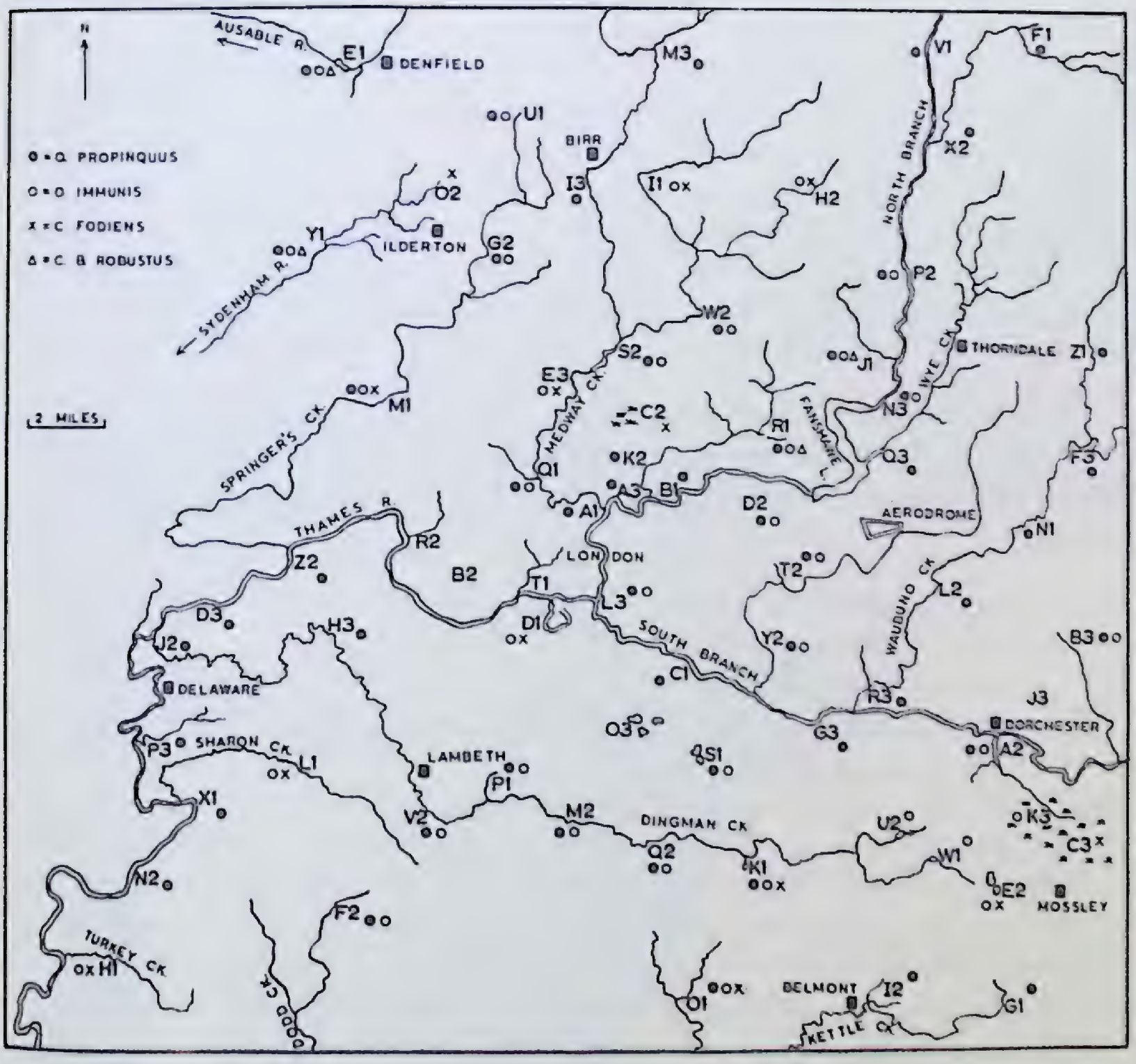

Figure 1 – Map of the vicinity of London, Ontario, showing collection sites (A1–Z1, A2–Z2, A3–R3) and species of crayfish collected at each site.

London and flow westward and then southward as one river. The map also shows several villages surrounding London. Collection site E1 was a pond on a tributary of the Ausable River, which flows into Lake Huron; sites Y1 and O2 were on a tributary of the Sydenham River, which flows into Lake Huron; and sites G1, O1, F2, and I2 were on tributaries of Kettle Creek, which flows into Lake Erie. All other sites were on individual ponds and swamps in the Thames watershed, on tributaries of the Thames River, or on the Thames River itself.

Collections were made by patrolling the banks of rivers and streams and the borders of ponds and swampy areas. A long-handled dip-net was used to capture specimens. Rocks, boards, logs, and other objects in the water were turned over in the search for specimens. In swampy places and along the borders of bodies of water, burrows and chimneys were looked for and excavated. Each collection locality was visited once during the season. Where the site was a stretch of stream or river, about one mile of its length was patrolled along one bank. During the summer Mr. John G. Ekins helped to collect, sort, and identify specimens. Keys in Crocker (1957), Edmondson (1959), François (1959), Huntsman (1915), and Pennak (1953) were used to identify these specimens. Four species were collected: *Cambarus bartoni robustus* Girard, *Cambarus fodiens* (Cottle), *Orconectes propinquus* (Girard), and *Orconectes immunis* (Hagen). All males were examined to determine the numbers of form I males (those capable of copulation) and form II males (those incapable of copulation); keys and descriptions in Crocker (1957) were used. In form I males the stylets of the first pleopods are heavier, more corneous, larger, and have larger hooks than in form II males. The specimens have been deposited in the collections of the Natural History Branch of the National Museum of Canada and of the Department of Zoology, University of Western Ontario.

The collection sites, dates of collection, and numbers of each species collected were as follows (the four numbers in brackets are the numbers collected of the four species, respectively, *Orconectes propinquus, O. immunis, Cambarus fodiens, C. b. robustus*):

A1, May 15, mouth of Medway Creek (5:0:0:0)
B1, May 17, North Branch (3:0:0:0)
C1, May 18, South Branch (11:0:0:0)
D1, May 19, The Coves, a backwater of the Thames River (0:1:2:0)
E1, May 20, Pond at Denfield (21:1:0:11)
F1, May 21, tributary of North Branch (25:0:0:0)
G1, May 25, tributary of Kettle Creek (3:0:0:0)
H1, May 26, Turkey Creek (0:7:9:0)
I1, May 27, tributary of Medway Creek (0:2:4:0)
J1, May 28, tributary of North Branch (4:2:0:5)
K1, May 31, pond by Dingman Creek (9:1:2:0)
L1, June 1, Sharon Creek (0:4:3:0)
M1, June 3, Springer's Creek (5:1:1:0)
N1, June 4, Waubuno Creek (6:0:0:0)
O1, June 7, tributary of Kettle Creek (8:1:1:0)

P1, June 8, Dingman Creek (4:8:0:0)
Q1, June 9, Medway Creek (5:1:0:0)
R1, June 10, tributary of North Branch (7:1:0:0)
S1, June 11, two ponds at Pond Mills (5:1:0:0)
T1, June 14, tributary of Thames River (0:0:0:0)
U1, June 15, tributary of Springer's Creek (4:9:0:0)
V1, June 16, North Branch (9:0:0:0)
W1, June 17, Beattie Pond (0:8:0:0)
X1, June 18, Thames River (9:0:0:0)
Y1, June 21, tributary of Sydenham River (4:3:0:1)
Z1, June 22, Waubuno Creek (12:0:0:0)
A2, June 23, pond at Dorchester (5:3:0:0)
B2, June 24, Byron Bog (0:0:0:0)
C2, June 25, marsh (0:0:13:0)
D2, June 28, white cedar swamp (1:11:0:0)
E2, June 29, Dingman Ponds (0:9:1:0)
F2, June 30, tributary of Dodd Creek (1:9:0:0)
G2, July 5, Springer's Creek (10:4:0:0)
H2, July 6, tributary of Medway Creek (0:16:1:0)
I2, July 8, Kettle Creek at Belmont (28:0:0:0)
J2, July 9, mouth of Dingman Creek (14:0:0:0)
K2, July 10, tributary of North Branch (3:0:0:0)
L2, July 12, Waubuno Creek (17:0:0:0)
M2, July 13, Dingman Creek (3:20:0:0)
N2, July 14, Thames River (7:0:0:0)
O2, July 15, tributary of Sydenham River (0:0:4:0)
P2, July 16, North Branch (14:2:0:0)
Q2, July 19, Dingman Creek (17:4:0:0)
R2, July 20, tributary of Thames River (0:0:0:0)
S2, July 21, pond on Medway Creek (3:8:0:0)
T2, July 22, tributary of South Branch (7:5:0:0)
U2, July 26, Foster Ponds (0:8:0:0)
V2, July 27, Dingman Creek (7:8:0:0)
W2, July 28, tributary of Medway Creek (7:4:0:0)
X2, July 29, mouth of tributary of North Branch (10:0:0:0)
Y2, July 30, tributary of South Branch (15:3:0:0)
Z2, August 3, Thames River (8:0:0:0)
A3, August 5, Thames River (9:0:0:0)
B3, August 6, tributary of South Branch (12:1:0:0)
C3, August 9, Dorchester Swamp (0:0:7:0)
D3, August 10, Thames River (8:0:0:0)
E3, August 11, Medway Creek (0:1:1:0)
F3, August 12, Waubuno Creek (13:0:0:0)
G3, August 13, South Branch (10:0:0:0)
H3, August 16, Dingman Creek (11:0:0:0)
I3, August 17, Medway Creek (9:0:0:0)
J3, August 18, marsh northeast of Dorchester (0:0:0:0)

K3, August 19, stream in Dorchester Swamp (3:3:0:0)
L3, August 20, "Forks" of the Thames River (6:1:0:0)
M3, August 23, Medway Creek (5:0:0:0)
N3, August 24, upper end of Fanshawe Lake (2:3:0:0)
03, August 25, three kettle lakes, Walker Ponds (0:0:0:0)
P3, August 26, mouth of tributary of Thames River (11:0:0:0)
Q3, August 30, Wye Creek (9:0:0:0)
R3, August 31, mouth of Waubuno Creek (12:0:0:0)

Altogether, there were collected 456 *O. propinquus* from 53 sites, 174 *O. immunis* from 36 sites, 49 *C. fodiens* from 13 sites, and 18 *C. b. robustus* from 4 sites.

Account of Species Collected

Orconectes propinquus (Girard)

This species was the commonest one collected. It was found at all types of sites except marshes and wet areas separated from open or running water, e.g., C2, C3. While occurring in most types of sites, it was commonest where running water passed over mud and gravel bottoms, unobstructed by vegetation. Thus this species was the commonest and frequently the only one found at sites along the broad reaches of the Thames River and its North and South Branches.

Altogether, 456 specimens were collected, 296♂♂ (65%) and 160♀♀ (35%), with the predominance of males persisting through the season. The largest male, 74 mm, and largest female, 75 mm, were captured on July 10 at site K2 on a tributary of the North Branch. Of all the males collected, 122 were form I (copulatory) and 174 were form II (non-copulatory). During May and June, form II males predominated in numbers, during July the two forms were almost equally represented, and during August form I males predominated. This seasonal distribution of the two forms is in accord with the observations on the male population of *O. propinquus* made by Creaser (1933) in Michigan. During the season 23 specimens had the right cheliped missing, 13 the left cheliped missing, 4 both chelipeds missing, 19 one or both chelipeds regenerating, and 30 one or more antennae missing. Thus 89 specimens, 20 per cent of the total, had suffered loss of appendages.

Mating habits of pairs of *O. propinquus* in their natural habitat were observed from July 29 to August 12. The first pair was noted on the stony bottom of the stream, site X2, on July 29 at 9.56 a.m. The female was lying on her back with the male on top grasping her left cheliped with his right cheliped and her second and third right pereiopods with his left cheliped. When the pair was interrupted by another crayfish, the male dragged the female under a rock, and the mating continued till 10.56 a.m. when the pair was collected. On July 30 at site Y2 14 pairs were seen mating on the muddy bottom of the stream. On August 5 at site A3 one pair was seen mating; on August 6 at site B3 three pairs were seen mating, and on August 12 at site F3 four pairs were seen mating. It was also noted that during the end of July and throughout August specimens brought alive into the laboratory in their containers would actively engage in mating behaviour. This time of mating activity is in accord with the report of Crocker (1957), who records seeing mating pairs in New York from July 13 to October 19, with the main activity in July and August.

Females bearing clusters of eggs on their abdomens were collected from May 15–21. One female 36 mm long was collected at site A1 on May 15 bearing a cluster of 51 black eggs, each about 1.5 mm in diameter. On May 20 at site E1 three females 48 mm, 42 mm, and 49 mm long bore, respectively, clusters of 101, 57, and 76 eggs. On May 21 at site F1 two females 47 mm and 41 mm long bore, respectively, clusters of 110 and 4 eggs. Only one female collected bore young on the pleopods. She was found on June 4 at site N1; she was 58 mm long and was carrying 105 young, averaging 4 mm long, distributed along the lower surface of the abdomen and attached to the pleopods. This period of egg-bearing and production of young in the spring is in accord with Crocker's (1957) report from New York where egg-bearing females were collected from April 13 to May 25, and females with young were collected on June 21.

During the season four freshly moulted specimens with soft and pliable exoskeletons were collected: one form II male 52 mm long at site N1 on June 4, one form I male 63 mm long at site V1 on June 16, two females 58 and 57 mm long at site I3 on August 17.

Orconectes immunis (Hagen)

This species was found at all types of sites from swamps with little water to broad expanses of the Thames River. It was commonest on the upper reaches of streams where the water was shallow and the flow of water slow, and where rooted aquatic vegetation grew plentifully from the bottom and banks of the water course. Thus it was the commonest and sometimes the only species collected at sites which were shallow, weed-filled ponds, formed as expanses of the upper reaches of streams, e.g., W1, U2.

Altogether, 174 specimens were collected, 75♂♂ (43%) and 99♀♀ (57%), with the predominance of females persisting through the season. The largest male, 78 mm, was captured on June 21 at site Y1 on a tributary of the Sydenham River. The largest female, 87 mm, was captured on July 22 at site T2. Of all the males collected, eight were form I and 67 form II. Thus form II males predominated throughout the season; form I males were collected on May 31, June 15–21, July 26, and August 24. During the season eight specimens had the right cheliped missing, five the left cheliped missing, four both chelipeds missing, nine one or both chelipeds regenerating, and nine one or more antennae missing. Thus 35 specimens, 20 per cent of the total, had lost appendages.

No mating by pairs of this species was noted. Only one female was found bearing eggs. She was collected on May 27 at site I1 and bore on her abodmen three brown eggs, each 1.5 mm in diameter. Crocker (1957) records that females bearing eggs were collected in New York State in April and May. On May 26 at site H1 a female, 62 mm long, was found with one young, 6 mm long, attached to her pleopods. This record is in accord with the report of Crocker (1957) that a female bearing young was found in New York State in May.

During the season five freshly moulted specimens with soft and pliable exoskeletons were collected: one female 56 mm long at site H2 on May 26, one female 63 mm long at site J1 on May 28, one form II male 32 mm long at site

H2 on July 6, one form II male 48 mm long at site Y2 on July 30, one form I male, 69 mm long at site N3 on August 24.

Cambarus fodiens (Cottle)

At ten of the sites where this species was found, all specimens were dug from burrows in the damp mud of swamps and marshes or from the banks of bodies of water. In places where they were collected in June, July, and August, many of the burrows were surmounted by chimneys, the area around the burrows being composed of partly dried mud. At the only two sites, apart from burrows, where *C. fodiens* was found, the specimens were in shallow water in pools of a drying stream, L1, and among weeds in a shallow pond, E2.

Altogether, 49 specimens were collected, 22♂♂ (45%) and 27♀♀ (55%). The largest male, 47 mm, was captured on May 31 at site K1 and the largest female, 70 mm, on May 27 at site I1. Of all males collected, 21 were form II and one was form I (May 31). During the season, six specimens had the right cheliped missing, two the left cheliped missing, ten had one or both chelipeds regenerating, and nine had one or more antennae missing. Thus 27 specimens, 55 per cent of the total, had lost appendages.

No mating pairs were noted, no females were seen carrying eggs or young, and no freshly moulted specimens were noted.

Cambarus bartoni robustus Girard

Examples of this species were found at four sites. The largest collection was from Denfield Pond, E1, where 11 large specimens were found under boards floating in shallow water or settled into the damp mud at the edge of the pond. The other specimens were collected at three sites, J1, R1, Y1, from beneath rocks in streams with shallow water and slow flow.

Altogether, 18 specimens were collected, 6♂♂ (35%), 11♀♀ (65%), and one specimen of undetermined sex. The largest male, 91 mm, and the largest female, 91 mm, were captured at site E1 in Denfield Pond. Two of the males were form I (May 20, 28) and three form II (May 20). During the season one specimen was collected with both chelipeds missing, three with one or both chelipeds regenerating, and one with an antenna missing. Thus five specimens, 29 per cent of the total, had lost appendages.

No mating activity was noted in this species, no females were seen with eggs or young, and no freshly moulted specimens were noted.

Animals Associated with the Crayfish

As the crayfish were being collected and examined, other species of animals found with them were also collected. These were leeches found in dead crayfish, worms (Branchiobdellidae) clustered on the crayfish, and eggs of water-boatmen (Corixidae) on the appendages. The leeches were identified by Dr. M.C. Meyer, Department of Zoology, University of Maine, Orono, Maine, and the worms by Dr. P.C. Holt, Department of Biology, Virginia Polytechnic Institute, Blacksburg, Virginia.

HIRUDINEA

ERPOBDELLIDAE

Erpobdella punctata (Leidy)

Five leeches were found in the bodies of three dead *Orconectes immunis.* One was in the body of a female crayfish on May 19 in The Coves (D1), and on June 15 two were in the thorax of a male crayfish, and two were under the carapace of a female crayfish in Springer's Creek (U1). In both these localities the specimens were collected from still or slowly flowing water among weeds. *E. punctata* is a common leech in North America (Oliver 1958; Pennak 1953). Ryerson (1915) reports it as the leech "most commonly taken" in collections from Georgian Bay, Ontario, Pennak (1953) points out that leeches of the family Erpobdellidae never have true jaws and that, while they occasionally suck blood from fish and frogs, they feed mostly on small invertebrates and are scavengers. It is thus likely that the five leeches found in the bodies of the three *O. immunis* were scavenging on the dead remains of these crayfish.

OLIGOCHAETA

BRANCHIOBDELLIDAE

Branchiobdellid worms were found clustered on the lower surface of some crayfish, mainly about the bases of the walking legs of the cephalothorax. Twenty collections of crayfish included such worms. In some cases the numbers of worms were counted from individual crayfish, while in other instances the worms were found in jars containing several crayfish from one collection. Some worms were identifiable to species or genus, while others were unidentifiable, because they had been crushed in collection or adversely affected by the preservative. The following list shows the numbers of worms collected from the crayfish, with the names given by Dr. Holt:

May 15 – (A1) – 4 *Cambarincola* sp. from 1 *O. propinquus*
May 20 – (E1) – 66 including some *Cambarincola fallax* from 11 *C. robustus*
May 20 – (E1) – 2 unidentified from 1 *O. propinquus*
June 7 – (O1) – 3 ? *Pterodrilus* sp. from 1 *O. propinquus*
June 22 – (Z1) – 8 unidentified from 1 *O. propinquus*
June 23 – (A2) – 2 ? *Pterodrilus* sp. from 1 *O. propinquus*
July 26 – (U2) – 24 unidentified from 8 *O. immunis*
July 27 – (V2) – 4 ? *Pterodrilus* sp. from 1 *O. propinquus*
July 29 – (X2) – 12 *Cambarincola fallax* from 10 *O. propinquus*
July 30 – (Y2) – 14 unidentified from 15 *O. propinquus*
Aug. 5 – (A3) – 3 ? *Pterodrilus* sp. from 1 *O. propinquus*
Aug. 6 – (B3) – 6 unidentified from 12 *O. propinquus*
Aug. 12 – (F3) – 3 unidentified from 1 *O. propinquus*
Aug. 13 – (G3) – 10 *Pterodrilus distichus* from 10 *O. propinquus*
Aug. 16 – (H3) – 22 ? *Pterodrilus* sp. from 13 *O. propinquus*
Aug. 17 – (I3) – 7 unidentified from 9 *O. propinquus*
Aug. 20 – (L3) – 2 unidentified from 1 *O. propinquus*

Aug. 23 – (M3) – 3 unidentified from 1 *O. propinquus*
Aug. 30 – (Q3) – 4 unidentified from 1 *O. propinquus*
Aug. 31 – (R3) – 16 unidentified from 12 *O. propinquus*

During most of the study period from May to August, worms were found on all three of the stream-dwelling species, *O. propinquus, O. immunis,* and *C. robustus,* but were not found on the burrowing *C. fodiens.* As many as eight worms were found on a single specimen (June 22) of the host. The commonest crayfish, *O. propinquus,* harboured the two identified species, *Cambarincola fallax* Hoffman and *Pterodilus distichus* Moore as well as other unidentified worms. Goodnight (1940) concludes that these worms display no host specificity and that each may occur on several species of host. The host crayfish were collected from a wide variety of habitats, thus indicating that the distribution of worms is not dependent upon the type of aquatic habitat. Goodnight (1940) concludes that the distribution of branchiobdellids in a stream is independent of its size and drainage area. The two identified species are reported as commonly found on crayfish, *Pterodrilus distichus* being "widely distributed" in eastern North America (Pennak 1953) and *Cambarincola fallax* occurring in collections from New York state to Georgia (Hoffman 1963).

INSECTA

CORIXIDAE

Eggs of water-boatmen were found clustered on the anterior part of the thorax and on the chelipeds and antennae of several crayfish gathered during most of the collecting season. They were present on 21 *C. fodiens* on 7 days, on 80 *O. propinquus* on 27 days, and on 60 *O. immunis* on 16 days, but none were found on *C. robustus.* Several dozen eggs were present on some specimens, but no crayfish were so heavily laden with eggs as the one pictured by Meyer (1965). He shows a crayfish with the whole anterior end covered with eggs. Usinger (1956) refers to the corixids' habit of laying eggs on crayfish and points out that the protection of eggs from drought and enemies is a possible benefit of this association. The concentration of eggs on the anterior appendages may be related to the association of the insects with species living in burrows and frequenting potholes (Meyer 1965; Usinger 1956). Both Meyer (1965) and Usinger (1956) refer to the corixid *Ramphocorixa acuminata* as a species particularly addicted to laying eggs on crayfish. This species has not been collected in Ontario (Hungerford 1948). Since no corixids were gathered during the collecting of crayfish at London, the species involved in the egg-laying remains unknown.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

POISONOUS AND VENOMOUS FISHES OF CANADA

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POISONOUS AND VENOMOUS FISHES OF CANADA

D.E. McALLISTER

RÉSUMÉ

La présente étude énumère les espèces de poissons des eaux canadiennes que l'on croit être toxiques. Une illustration de la plupart des espèces, la mention des eaux canadiennes qu'elles habitent et certaines remarques sur l'endroit, la nature et le traitement des empoisonnements font partie de cette étude. On pense que les espèces suivantes ont une chair vénéneuse: *Somniosus microcephalus, Fundulus diaphanus, Fundulus heteroclitus, Lagocephalus lagocephalus, Sphaeroides maculatus* et *Chilomycterus schoepfi.* Les espèces de poissons à gonades vénéneuses sont: *Hydrolagus colliei* et *Scorpaenichthys marmoratus.* Le sang frais de l'*Anguilla rostrata,* s'il est assimilé par l'organisme humain, est probablement vénéneux. On croit venimeux certains poissons dont les toxines pénètrent l'organisme humain au moyen d'épines, notamment *Squalus acanthias, Dasyatis dipterurus, Dasyatis centroura, Dasyatis violacea, Hydrolagus colliei,* Ictaluridae (surtout *Noturus*) et *Porichthys notatus.* Aucun cas de mortalité attribuable à des poissons vénéneux ou venimeux n'est connu au Canada.

INTRODUCTION

This paper lists and figures the fishes of Canada that are known to be poisonous to man. It describes, as far as is known, the site and nature of the poison. There are few toxic fishes in Canada. Only twelve of Canada's 770 species of freshwater and marine fishes are noxious. Most of these twelve are rare or of a type that most people would not ordinarily come in contact with. None of the species commonly caught for sport or by commercial fishermen are harmful to eat. As far as is known there are no cases in Canada of death from poisonous or venomous fishes.

TYPES OF FISH POISONING

There are several basic types of fish poisoning. A major type of fish poisoning results from eating parts of a fish. Fishes of which some part is toxic are called *poisonous fishes.* Three types of poisonous fishes are found in Canada. The most common are those whose flesh is poisonous; poisoning from eating this flesh is called *ichthyosarcotoxism.* In some fishes the poison is restricted to the gonads (the musculature and other parts are usually edible); poisoning from these fishes is *ichthyootoxism.* Other fishes have poisonous blood (the poison is usually destroyed by heat and by gastric juices); poisoning from this source is *ichthyohemotoxism.*

A second major type of poisoning results not from eating the fish, but by being punctured by certain spines on the head or fins and by the entry of toxins from an associated gland or tissue. This type of poisoning is *ichthyoacanthotoxism.* All the above types of fish poisoning fall under a more general term, *ichthyotoxism.* Poisoning from fish rendered toxic by bacterial action, or food poisoning, is outside the scope of this article. *Ciguatera poisoning,* associated with tropical reef fishes, is unknown in Canada. A worldwide monographic treatment of fish poisoning is given by Halstead (1967).

IDENTIFICATION OF TOXIC FISHES

Identification of fish specimens may be made from the references listed at the end of the text. The curator of fishes at the National Museum of Canada or at several provincial museums, as well as scientists in biology or zoology departments of universities and in the Fisheries Research Board of Canada, Department of Fisheries, or in provincial fish and game departments are usually able to provide identifications of specimens suspected of being poisonous or venomous. Specimens may be preserved by being frozen or placed in a solution of 10 per cent formalin (1 part of concentrated formalin + 9 parts of water).

LIST OF TOXIC FISHES

Below are listed under two major headings, *Poisonous Fishes* and *Venomous Fishes,* all those fishes in Canada known to be toxic. They are listed in phylogenetic order, with the more primitive species first. One might also mention here two species which, although not toxic, can give electric shocks. The Atlantic torpedo or torpille noire, *Torpedo nobiliana,* has been recorded only once in Canada, from Fox Point, southern Nova Scotia. The Pacific electric ray, *Torpedo californica,* has been recorded about ten times near Vancouver Island and the Queen Charlotte Islands, British Columbia. Voltages of up to 220 volts have been measured for the Atlantic torpedo. Discharges can produce a numbing or tingling feeling, or cause muscular contraction of the contacting arm or leg.

I. POISONOUS FISHES

A. Fishes with Poisonous Flesh

Greenland shark, *laimargue (Somniosus microcephalus)*

Description and figure. Leim and Scott (1966).

Canadian distribution. Marine. From the Bay of Fundy north to Baffin Bay; it is rare south of Labrador.

Notes. There are no reports of poisoning from this species in Canada, but cases are well documented in nearby Greenland where it is eaten by humans and sled dogs. Meat can be detoxified by being cut in strips and hung until quite dry, especially if it is frozen and then dried thoroughly in the sun or wind. It can also be detoxified by being boiled in three or four different changes of water, or by being left to hang until some fluid drops off and the flesh begins to putrify.

Symptoms of poisoning are those of intoxication. In dogs it causes stiff walking; vomiting; and spurting watery, fetid diarrhoea. The eyes become red and turned up and outwards. The toxin may interfere with walking or may produce convulsions and may oause death apparently as a result of respiratory paralysis. The toxin appears to be a nerve poison, similar in effects to muscarine in the fly-mushroom, *Amanita muscaria.*

The poison apparently originates from pteropods, small shell-less molluscs which swim in open water. In Greenland the shorthorn sculpin, *Myoxocephalus scorpius,* and the Greenland halibut, *Reinhardtius hippoglossoides,* are sometimes observed to have similar symptoms after they ingest pteropods. (Above information primarily from Bøje 1939).

Banded killifish, *petit barré (Fundulus diaphanus)*

Mummichog, *choquemort (Fundulus heteroclitus)*

FIGURE 1 Banded Killifish

FIGURE 2 Mummichog

Description and figure. Scott (1967) or Leim and Scott (1966).

Canadian distribution. The banded killifish is found in fresh waters of southern Canada in Manitoba (rare), Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland. The mummichog is found in brackish and salt waters of Quebec, New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland.

Notes. There is apparently no record that these two small fishes have poisoned humans. It is inferred, however, that they may contain poison because birds and mammals often have refused to eat them and because animals which did consume them became ill.

Symptoms include immobility in birds and bloody diarrhoea in foxes.

A test for paralytic shell poison in mummichogs was negative, but of course another poison might be present. (Above account *from* White, Medcof, and Day 1965.)

Oceanic puffer, ***orbe étoilé (Lagocephalus lagocephalus)***

Northern puffer, ***sphéroide du nord (Sphaeroides maculatus)***

FIGURE 3 Northern puffer

Description and figure. Leim and Scott (1966).

Canadian distribution. Marine. Very rare on the Atlantic coast of Canada. The oceanic puffer was recorded once in Placentia Bay, Newfoundland; the northern puffer was recorded twice, once in Hermitage Bay, Newfoundland, and once in waters near Kingsport, Nova Scotia.

Notes. I do not have specific data on the toxicity of these two species. Elsewhere about forty species of the puffer family are well known for their toxicity. In Japan, there is considerable literature on the toxicity of these fish. In that country the puffers are considered a special culinary delicacy, but because their poison is well known, only specially licensed restaurants are allowed to serve them. The ovaries and liver of these fish are extremely poisonous, the intestines and skin less so.

The first symptom of *tetrodont*, or *puffer poisoning*, which develops about half an hour after the fish is eaten, is numbness of the lips, tongue, and tips of extremities. This may be followed by nausea, vomiting, headache, and dizziness. The patient becomes so weak that he can not stand. His speech and breathing are impaired. After two hours he suffers paralysis, his muscles are relaxed, and he is unable to speak. Death from respiratory paralysis may occur in 1 to 24 hours.

Mortality rate is about 60 per cent. If the patient survives 24 hours, the prognosis is considered good (*from* Halstead and Lively 1954.)

The poison, *tetrodontoxin*, first blocks the conduction of nerve signals; then it affects the contraction of the muscle fibres. The structure of tetrodontoxin has now been described. Its empirical formula is $C_{11}H_{17}N_3O_8$ (*from* Fuhrman 1967).

Striped burrfish, *atinga barriolé (Chilomycterus schoepfi)*

Description and figure. Leim and Scott (1966).

Canadian distribution. Marine. Only one Canadian record, a 3-inch specimen from near Halifax, Nova Scotia, in 1896.

Notes. The flesh of most of the members of this family is said to be poisonous (Bigelow and Schroeder 1953*a*).

B. Fishes with Poisonous Gonads

Ratfish *(Hydrolagus colliei)*

FIGURE 4. Ratfish

Descriptions and figures. For the ratfish *see* Clemens and Wilby (1967), for Atlantic chimaeras *see* Leim and Scott (1966).

Canadian distribution. Marine. Common all along the coast of British Columbia at moderate depths. The Atlantic chimaeras occur from the Grand Banks southwards but are infrequently caught as they are seldom taken shallower than 250 fathoms.

Notes. The following experiments were on the ratfish but might apply to the Atlantic chimaeras, which are in the same family. Extracts from the muscle, liver, and oviduct, injected intraperitoneally into mice, showed only the oviduct to be toxic. This would suggest that the reproductive organs should be removed before cooking and not be eaten (*from* Halstead and Bunker 1952).

Cabezon *(Scorpaenichthys marmoratus)*

FIGURE 5 Cabezon

Description and figure. Clemens and Wilby (1967).

Canadian distribution. Marine. Coast of British Columbia.

Notes. The flesh is of excellent quality and harmless. The roe, or eggs, are toxic however. There is one known instance of poisoning from the roe in California. Experimental feeding of roe to rats and guinea pigs resulted in the deaths of four out of twelve rats and one out of two guinea pigs.

Humans who ingested the eggs of a specimen became violently ill four hours later. Their symptoms were rapidly alternating chills and fever, with frequent vomiting and diarrhoea. They were ill throughout the night, and they recovered the next day. Test animals suffered diarrhoea and nasal discharge (*from* Hubbs and Wick 1951).

C. Fishes with Poisonous Blood

American eel, *anguille d'Amerique (Anguilla rostrata)*

Description and figure. Scott (1967) or Leim and Scott (1966).

Canadian distribution. Catadromous. From the U.S. border north to Hamilton Inlet, Labrador, in salt and fresh waters.

Notes. Cooked eel flesh is of course not poisonous but is a well-known delicacy. I have no data on the American eel, but the European eel, *Anguilla anguilla*, and the moray eel of Europe are known to have a toxin in their blood. The poison has been called *ichthyotoxine.* Persons with skin abrasions on their hands, who come in contact with fresh eel blood, develop inflammation, mortification, suppuration, and sometimes oedema, complicated by lymphangitis and infiltration. Experimental work on animals has shown several distinct factors: (1) a neurotoxic action which results in cessation of breathing and heart beat when the animals are injected with the blood diluted in physiological saline; there would be no effect if the poison were taken through the mouth; (2) a cytolytic action which causes degeneration of the walls of the urinary tubes and haemolysis; and (3) an anti-coagulation action which is brought on indirectly through stimulation of the liver to secrete an anti-coagulating diastase (*from* Bertin 1956).

II. VENOMOUS FISHES

The following fishes have sharp spines on the skull or in the fins, which can puncture the skin and introduce poison from a gland or tissue. Although pricks from these spines can be irritating and painful and can cause local swelling, serious effects or deaths have not been reported in Canada. Toxicity of some species is not predictable; only some people react unfavourably to pricks from the dorsal spines of rockfish (Scorpaenidae) and greenling (Hexagrammidae).

Spiny dogfish, ***aiguillat commun (Squalus acanthias)***

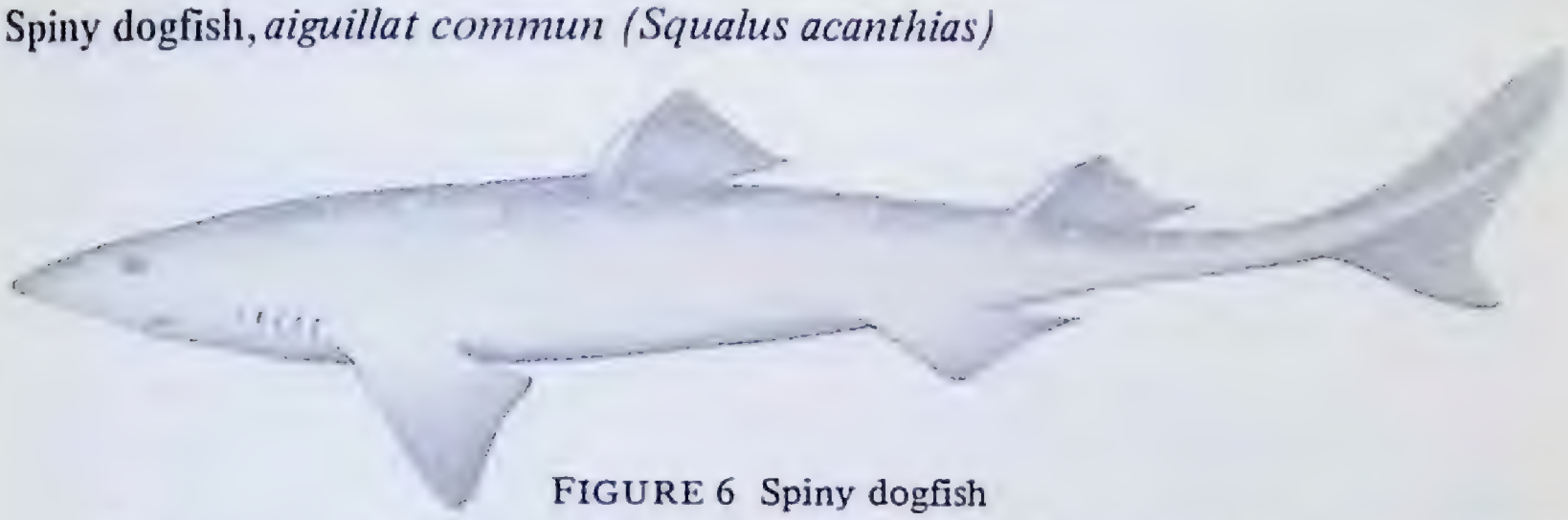

FIGURE 6 Spiny dogfish

Description and figure. Clemens and Wilby (1967) or Leim and Scott (1966).

Canadian distribution. Marine. In the Atlantic from the Bay of Fundy to southern Labrador and in the Pacific in the coastal waters of British Columbia.

Notes. In front of each of the two dorsal (or back) fins is a spine. It is probable that these spines are slightly poisonous. However, in one experiment, a person's skin was punctured and no reaction was produced (Halstead and Bunker 1953). The concave hind surface of the spines is sheathed with a glandular tissue resembling the poison glands of the venomous European weaver *(Trachinus draco)* (*from* Bigelow and Schroeder 1948).

Diamond stingray ***(Dasyatis dipterurus)***

Roughtail stingray ***(Dasyatis centroura)***

Pelagic stingray, ***pastenage violette (Dasyatis violacea)***

FIGURE 7 Roughtail stingray

Descriptions and figures. Clemens and Wilby (1967) and Leim and Scott (1966).

Canadian distribution. Marine. The diamond stingray is known from southern British Columbia; several specimens were reported off Kyuquot, British Columbia. in 1928, but none since.

The roughtail stingray is doubtfully known from a report from Upper Cape, New Brunswick.

The pelagic stingray has been taken 104 times off the southern Atlantic coast of Canada (*in litt.* Dr. W. B. Scott).

Notes. The enlarged serrated spine on the tail of stingrays is capable of inflicting a nasty wound. Deaths from stingray attacks have been recorded outside of Canada by a number of authors. When driven by the muscular tail, the spine can pierce a heavy boot. A true venom is secreted from tissue lying in lateral grooves along the side that faces the tail.

Symptoms include pain and swelling and appear soon after the wound is inflicted.

The wound should be cut open, bleeding encouraged, and suction applied. Prolonged soaking of the injured limb in epsom salt (or ordinary table salt) in very hot water is perhaps the best home remedy (*from* Bigelow and Schroeder 1953; Halstead and Bunker 1953).

Ratfish *(Hydrolagus colliei)*

Descriptions and figures. For Pacific ratfish *see* Clemens and Wilby (1967); for Atlantic chimaeras *see* Leim and Scott (1966).

Canadian distribution. Marine. The Pacific ratfish is commonly found all along the coast of British Columbia at moderate depths. The Atlantic chimaeras are infrequently caught from the Grand Banks southward, as they are seldom taken shallower than 250 fathoms.

Notes. The following observations are from experiments on the Pacific ratfish but might be applicable to the Atlantic chimaeras. A long, sharp serrate spine forms the front of the first dorsal (or back) fin. A test scratch produced an area of ischemia with raised borders followed by a zone of erythema and a mild dull ache lasting about ten minutes. Extracts from tissue connected to the spine killed mice in 24 to 54 hours. The venom is probably not very potent to man, and it is doubtful that it is capable of injuring him fatally (*from* Halstead and Bunker 1952).

Catfish family, *famille des barbottes* (ICTALURIDAE)

Description and figure. Scott (1967).

Canadian distribution. One or more species of bullhead or catfish (barbotte or barbue) of the genus *Ictalurus* occurs in at least the southern parts of all Canadian provinces, except Alberta, Prince Edward Island, and Newfoundland. One to three species of madtom or stonecat (chat-fou or barbotte des rapides) of the genus *Noturus* occur in southern parts of Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Notes. There is a sharp and sometimes serrate spine at the beginning of both the dorsal and pectoral fins. Glandular tissue on the spines may produce a toxin. The axillary gland located just above the base of the pectoral fin can secrete a poison, which can be transferred to the pectoral spine. The sting is weaker in *Ictalurus* than in *Noturus.* In *Noturus* the following effects have been described (Reed 1907). Pain resulting from this sting is comparable to that of the sting of a bee. It is usually confined to the wounded region, but a finger sting may cause pain in the hand and wrist, and occasionally deep punctures result in sharp pain extending as far as the elbow. Swelling is scarcely perceptible except after very severe punctures.

Midshipman *(Porichthys notatus)*

FIGURE 8 Midshipman

Description and figure. Clemens and Wilby (1967).

Canadian distribution. Marine. All along the coast of British Columbia at shallow and moderate depths.

Notes. The spine on the gill cover (operculum) is sharp and probably capable of toxic action. Toxic action has not been reported for this species but is known for the related Atlantic midshipman, *Porichthys porosissimus.* What is known of the Atlantic midshipman is the basis of the following observations. The opercular spine can be erected. When the spine is erected the skin sheath slides back. The pointed spine is grooved dorsally. The groove widens at the base of the spine and contains a yellow pulpy mass, which may be the poison gland.

The effects of a puncture in the palm of the hand have been described as follows. The pain is severe but of short duration. The pain is felt a few seconds after the puncture; it travels rapidly up the arm to the shoulder where it lasts for about fifteen minutes, then subsides over the next fifteen minutes. Similar patterns of pain have been felt by three people who were punctured.

Pinfish, *Lagodon rhomboides,* punctured by the spines of Atlantic midshipmen showed immediate signs of stress, lying on their sides, gasping, and swimming with heads down. Disorientation lasted about fifteen minutes, then they began to recover. In 20 minutes they had all righted themselves and in 30 minutes appeared recovered (*from* Lane 1967).

SUMMARY

This paper lists those fishes of Canadian waters believed to be toxic. For most species are provided an illustration, the Canadian distribution, and notes on the site, nature, and treatment of the poison. The flesh of the following species is believed to be poisonous to eat: *Somniosus microcephalus, Fundulus diaphanus, Fundulus heteroclitus, Lagocephalus lagocephalus, Sphaeroides maculatus,* and *Chilomycterus schoepfi.* Fish with gonads that are poisonous to eat are: *Hydrolagus colliei* and *Scorpaenichthys marmoratus.* If introduced into the body, the fresh blood of *Anguilla rostrata* is probably poisonous. Fishes believed to be venomous (toxins introduced into the body by spines) are: *Squalus acanthias, Dasyatis dipterurus, Dasyatis centroura, Dasyatis violacea, Hydrolagus colliei,* Ictaluridae (especially *Noturus*), and *Porichthys notatus.* No deaths in Canada are known to have resulted from poisonous or venomous fishes.

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The author gratefully acknowledges criticism of the manuscript by Dr. Bruce W. Halstead, World Life Research Institute, Colton, California; Dr. E. David Lane, Department of Lands and Forests, Maple, Ontario; Dr. S.U. Qadri, University of Ottawa, Ontario; and Dr. W.B. Scott, Royal Ontario Museum, Toronto, Ontario.

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NATIONAL MUSEUM OF CANADA **NATURAL HISTORY PAPERS**

A New Species of the Genus *Macoma* (Pelecypoda) from West American Coastal Waters, with Comments on *Macoma calcarea* (Gmelin 1791)

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and

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A NEW SPECIES OF THE GENUS *MACOMA* (PELECYPODA) FROM WEST AMERICAN COASTAL WATERS, WITH COMMENTS ON *MACOMA CALCAREA* (GMELIN 1791)

By Robert M. Dunnill* and Eugene V. Coan†

INTRODUCTION

In the course of an investigation, at the University of Victoria, on the occurrence and benthic ecology of species of the genus *Macoma* in British Columbia coastal waters, it became apparent that specimens identified as *Macoma calcarea* (Gmelin 1791) in collections at the University of Victoria and in newly-collected material consisted of two distinct species. Comparison of these species with specimens from the North Atlantic showed one species to be identical with *M. calcarea* in size, shell shape, and spermatozoan morphology and the other to be different from *M. calcarea* in maximum size attained, shell shape, and size and shape of the spermatozoa.

Concurrently, a nomenclatural and taxonomic revision of the West American Tellinacea was undertaken by Coan at Stanford University. Study at other museums in the United States in the course of Coan's project showed differences between *M. calcarea* and the new species to be consistent in living material and in Pleistocene fossil material.

The present description of the new species results from the independent studies by Dunnill and Coan.

Figure 1 shows the positions of the shell measurements referred to in the description of the new species and used in the preparation of Figure 5. Measurements by Coan of type specimens are of their maximum lengths.

I *MACOMA ELIMATA*, NEW SPECIES

Figures 2a - d, 3 (Holotype); 2e (Paratype)

Synonymy

Macoma calcarea (Gmelin), *auctt., non Tellina calcarea* Gmelin 1791: 3237 (48)

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Among others, the following basic West American publications on the Recent Pelecypoda, all "in part":

Dall 1900: 307

Dall 1916: 36

Dall 1921: 47

Oldroyd 1925: 173 - 174 [Her figure, however, is of *M. brota* Dall 1916*a*]

Grant and Gale 1931: 369 - 370

Keen 1937: 33

Burch and Burch 1943: 19 - 20

Burch 1945(a): 11; 1945(b): 17 [Index]

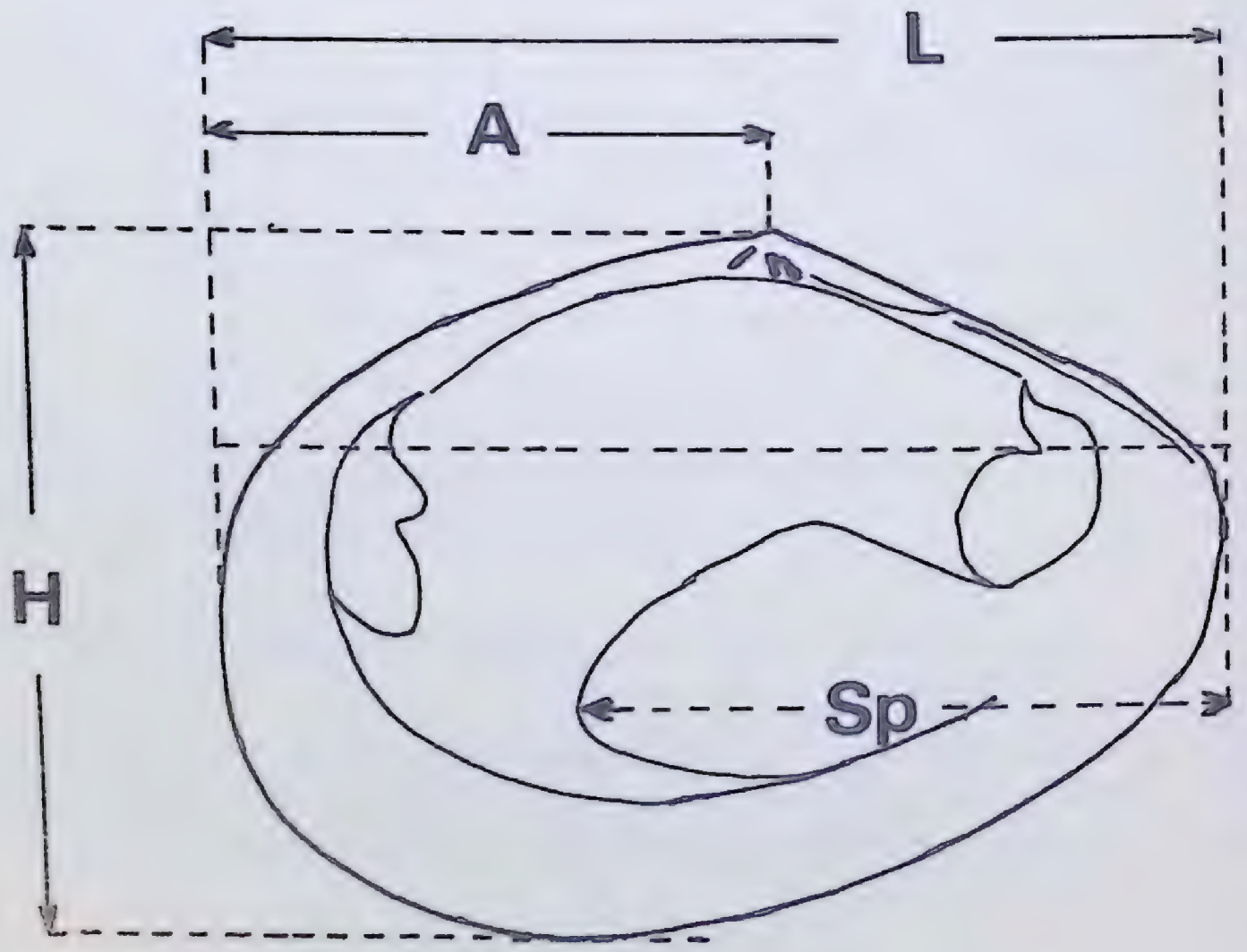

Figure 1 – Illustration of measurements taken from specimens. H = height, L = length, B = breadth, SP = length of pallial sinus, as measured in manner shown.

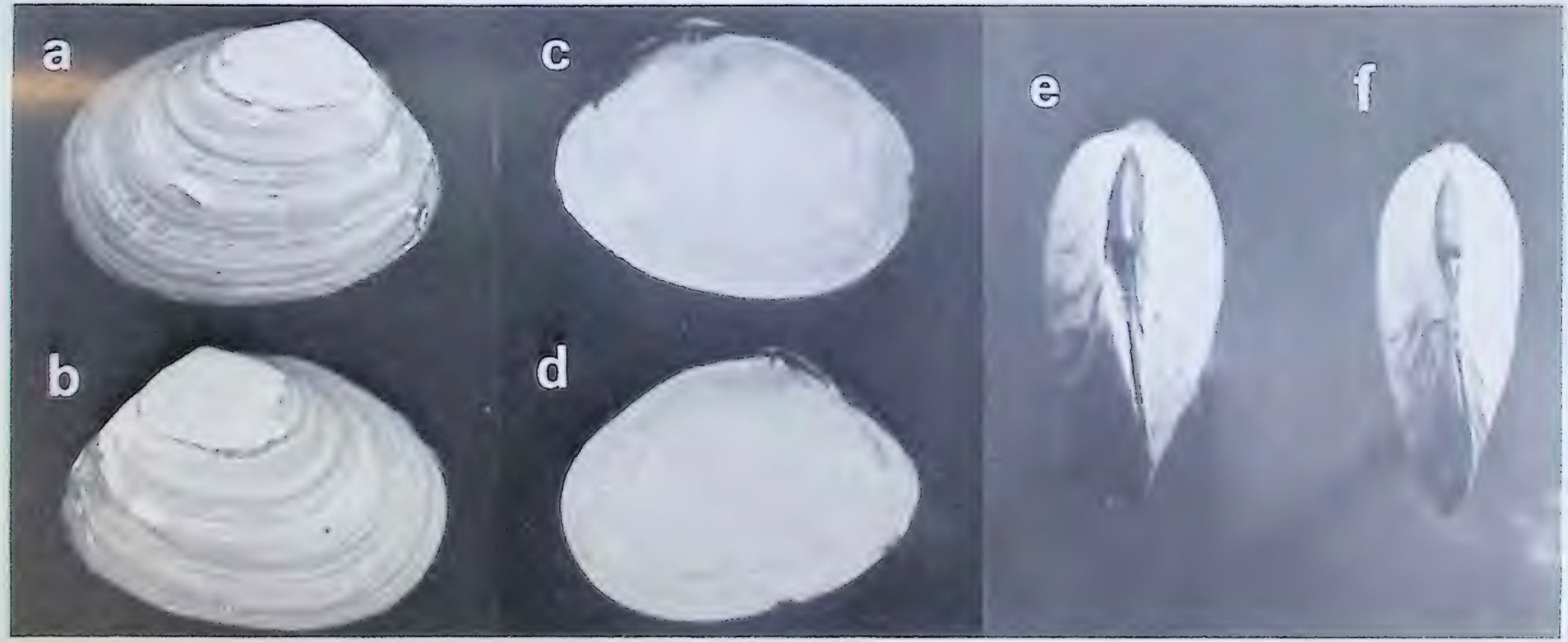

Figure 2 – a - d. *M. elimata,* Holotype, outside and inside of both valves. Length = 27.2 mm. Type lot is from the north end of Moresby Island, Satellite Channel, Vancouver Island, British Columbia, 49 metres.
e. *M. elimata,* Paratype, showing posterior dorsal margin. Length = 28.7 mm. Collection details as for figure 2a - d.
f. *M. calcarea,* showing dorsal margin. Length = 27.5 mm. Collection details as for figure 2a - d.

Probably also many southern Californian Pleistocene fossil records are of this species only, among others:

Crickmay 1929: 624 - 628, 631, as *"M. sp. nov. = M. calcarea* Arnold, 1903"

Clark 1931: 30, as *"M. calcarea* var."

Woodring, Bramlette, and Kew 1946: 84 [quoted below], pl. 33, fig. 6

See also Palaeontology section below.

Also reported from the Pleistocene in error as:

Macoma planiuscula Grant and Gale; Willett 1937: 61; *non* Grant and Gale 1931: 372, 908, 922 (plate explanations), pl. 14, fig. 11, pl. 20, fig. 8

Macoma "cf. M. nasuta Conrad," Keen and Bentson 1944: 13 (Table 1), *non Tellina nasuta* Conrad 1837: 258 - 259 (3)

Description of Holotype (Figures 2a - d, 3)

The new species is medium-sized for members of the genus *Macoma.* The largest of more than 200 specimens examined from the type locality is 32.9 millimetres long.

The shell is moderately inflated, reaching its maximum thickness well anterior to the umbos. The umbos are fairly prominent and are slightly raised above the dorsal margin. The shell is ovate anteriorly; posteriorly the dorsal margin is straight and steeply sloping. The posterior end is truncate. The periostracum is greenish grey and flaky and is little eroded except around the umbos. The shell is chalky white and is covered with fine, concentric growth lines. The posterior dorsal margin has a flattened, concave escutcheon. The valves are flexed toward the right posteriorly.

The interior is white with a low polish and a silky lustre. The pallial sinuses are discrepant, long in the left valve (stopping just short of the anterior adductor scar), much shorter and lower in the right valve. Both pallial sinuses loop back along the pallial line and are confluent with it beneath the umbos. The posterior cruciform muscle scar occurs near the ventral-posterior tip of the pallial line and divides into two parts, with a small anterior element. The anterior cruciform scar lies immediately ventral to the pallial line. There are two cardinal teeth in each valve. The left anterior and right posterior teeth are projecting and bifid, while the right anterior and left posterior teeth are projecting, lamellar, and fragile. The left posterior tooth is the thinnest and frequently breaks off when the valves are opened.

Size

The holotype is 27.2 mm long, 20.7 mm high, and 9.6 mm thick (both valves).

Paratypes and variation in specimens (paratype: Figure 2e)

Specimens have been noted with a red-brown periostracum, but the colour seems to be caused by preservation in isopropanol. Some individuals are relatively less inflated than the holotype.

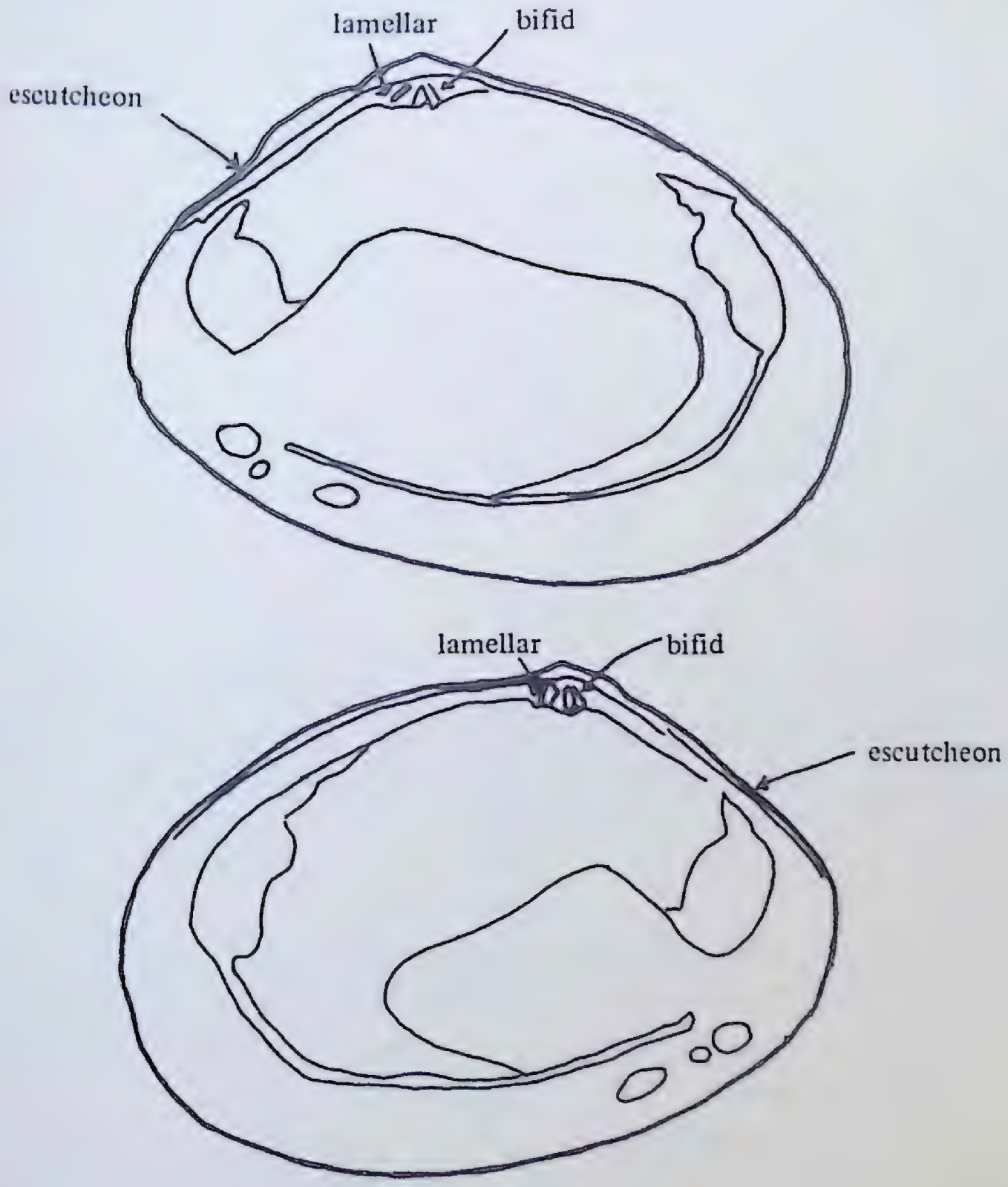

Figure 3 – *M. elimata*, Holotype, line drawing of inside of valves, Holotype length = 27.2 mm.

Type locality

The type lot is from the north end of Moresby Island, Satellite Channel, Vancouver Island, British Columbia (48°44′N by 120°19′W). The holotype was collected by Dunnill in silty sand at a depth of 49 metres on 7 June 1967. Paratypes were collected on 7, 27, and 28 June 1967 from 29 - 73 metres.

Deposition of types

The holotype is in the National Museum of Canada, Ottawa, Ontario. NMC 46070. Paratypes are in the National Museum of Canada (including Figure 2e); the United States National Museum, Stanford University (3 paratypes, SUPTC 9960); and the California Academy of Sciences (CASGTC 13099 and 13100).

Etymology

The name selected, *elimata,* an adjective (Latin: *elimare,* to file or to file away) describes the diagnostic character of the species, the filed-off appearance of the flattened or slightly concave escutcheon (Figure 2e).

Range (Figure 4)

Craig and Ketchikan, Alaska; throughout British Columbia; along the coasts of Washington, Oregon, and California as far south as Redondo Beach, Los Angeles County.

Ecology

M. elimata is abundant in the type locality and occurs in silty sands, clayey sand, and sand (terminology of Shepard (1954)). It has been found in various stations throughout its range from 15 to 476 metres. Both extremes of depth are in British Columbian stations. To our knowledge, there are approximately 65 Recent lots of this species in collections.

Palaeontology

M. elimata is common in the deep-water facies of the southern Californian Pleistocene, generally regarded as Early Pleistocene. Occurrences are as follows:

(1) The Timms Point Formation (marl and sand), from various stations, San Pedro, California

Arnold 1903: 161 (104), as *"M. calcarea."* The locality for the collection and the comments of later workers, such as Crickmay (1929), suggest that Arnold probably had *M. elimata,* but his figure does not seem to be of this species (p. 394, pl. 16, fig. 2) and his type specimen is lost.

Arnold 1906: 31, as *"M. calcarea"* (a repetition of the above)

Crickmay 1929: 624 - 628, 631, as *"M. sp. nov. = M. calcarea* Arnold, 1903." This worker found *M. elimata* commonly present in his "Zones 3, 4, & 6" and, by reworking of earlier strata, present in "Zones 7 & 8."

Clark 1931: 30, as *"M. calcarea"*

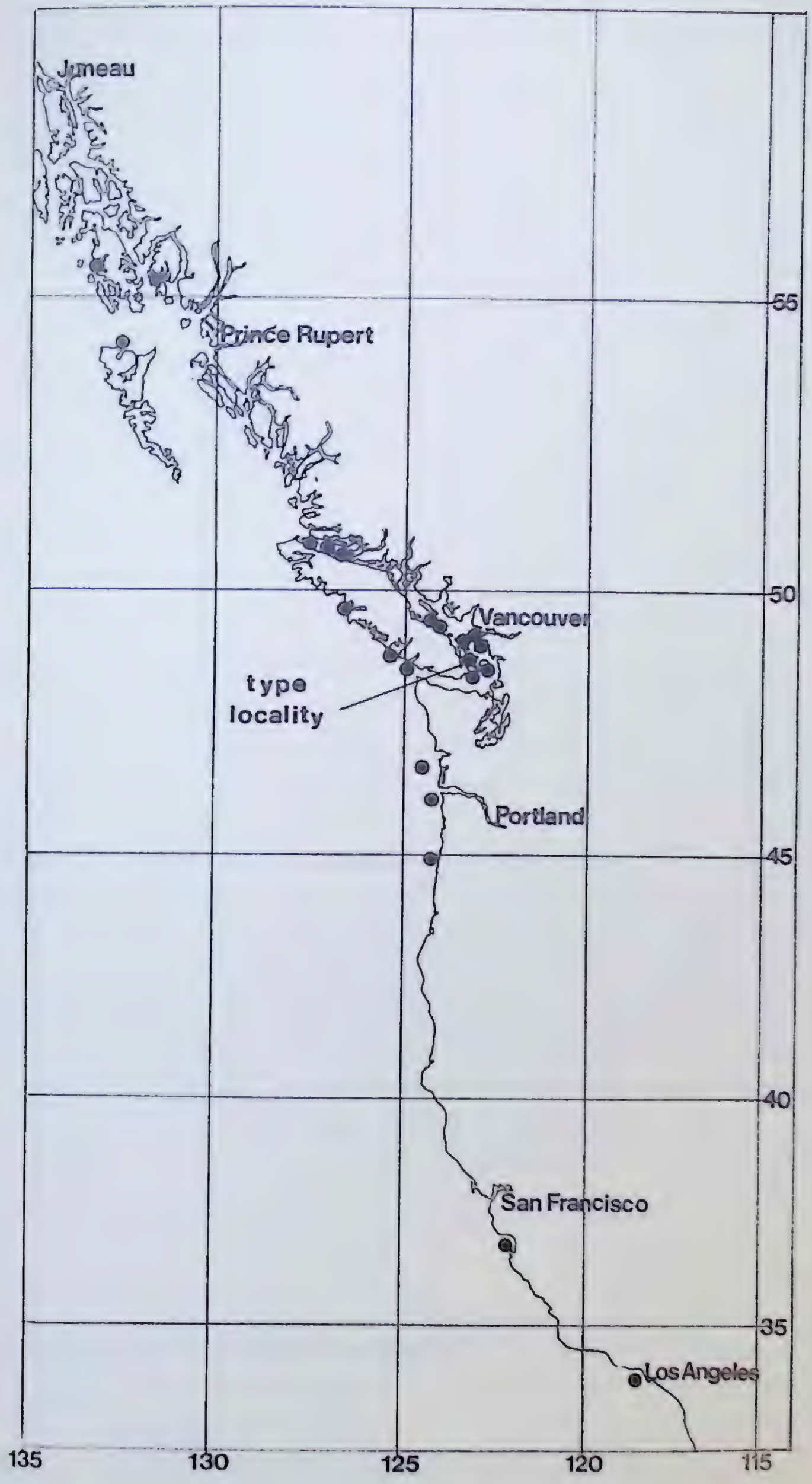

Figure 4 – Distributional map of *M. elimata* from southern Alaska to southern California.

Willett 1937: 61, as *"M. planiuscula"*

Woodring, Bramlette, and Kew 1946: 84, pl. 33 (6), as *"M. calcarea* var." Woodring says of it, "A small *Macoma* that has a short posterior end is identified as a small variety of *Macoma calcarea* (pl. 33, fig. 6). It is abundant and widespread in the Timms Point silt and is characteristic of that unit. The small *Macoma* (maximum length about 31 millimetres) appears to be identical with a small race of *M. calcarea* ranging from British Columbia to Monterey Bay (13 to 51 fathoms along the California coast). Perhaps it has been recorded as *M. planiuscula* (Dall's *carlottensis*, according to Grant and Gale), but that species is less inequilateral." There is little question that his figure is of our new species.

Valentine 1961: 407 (Table 33)

(2) The Anchor Silt, northwest Los Angeles, California
Rodda 1957: 2484, as *"M. calcarea"*

(3) Santa Barbara Formation, Santa Barbara, California
(?) Arnold 1907: 425, as *"M.* sp." [Bathhouse Cliff] Keen and Bentson 1944: 13 (Table 1), as *"M. cf. M. nasuta* (Conrad)"

Specimens of this Early Pleistocene material seen by Coan agree very well with the Recent species. Material from the Timms Point and Santa Barbara formations has been examined.

Records from the Late Pleistocene sands of southern California may be in error or may represent reworked material. Among these are the following:

Arnold 1906: 3, as *"M. calcarea,"* from the San Pedro Pleistocene

Stephens 1929: 251, 257, as *"M. calcarea,"* from the San Diego area. This was probably *Macoma nasuta* (Conrad), since the latter is unexpectedly missing from her lists.

The affinities of *M. elimata* to other species of *Macoma* in the Pliocene are currently being investigated by Dr. L.G. Hertlein of the California Academy of Sciences in connection with his study of the Pliocene of San Diego County, California. On this account, we will not examine the distribution of the species in the Pliocene or in those formations bridging the Pliocene - Pleistocene border not yet discussed. The species can probably be traced into the Early Pliocene, where it may have differed from typical *M. calcarea* by its elongated anterior end, but it apparently did not develop the strongly bevelled escutcheon until the Late Pliocene. The species probably became isolated from the main populations of *Macoma calcarea* (Gmelin) in the Early Pliocene.

Comparisons

(a) Shell morphology

M. elimata most closely resembles *M. calcarea* (Gmelin 1791), but it has a straighter dorsal margin posteriorly and a distinctive, flattened or slightly concave, deeply incised escutcheon. Figures 2e, f contrast the posterior dorsal margins of the two species.

M. elimata is a smaller species than *M. calcarea.* The largest of more than 200 specimens of *M. elimata* found at the type locality was 32.9 mm long. Specimens of *M. calcarea* from the same area were frequently more than 40 mm long, and one specimen was 47.6 mm.

The graphs (Figure 5) plot total length versus thickness, total length versus anterior length, and total length versus height. The measurements were taken from 25 specimens each of *M. elimata* and *M. calcarea* from Satellite Channel, Vancouver Island, British Columbia, and 15 specimens of *M. calcarea* from Strømfjord, western Greenland. The slopes of the regression lines are very similar and indicate that these two species are not easily separable on the basis of these sets of shell measurements.

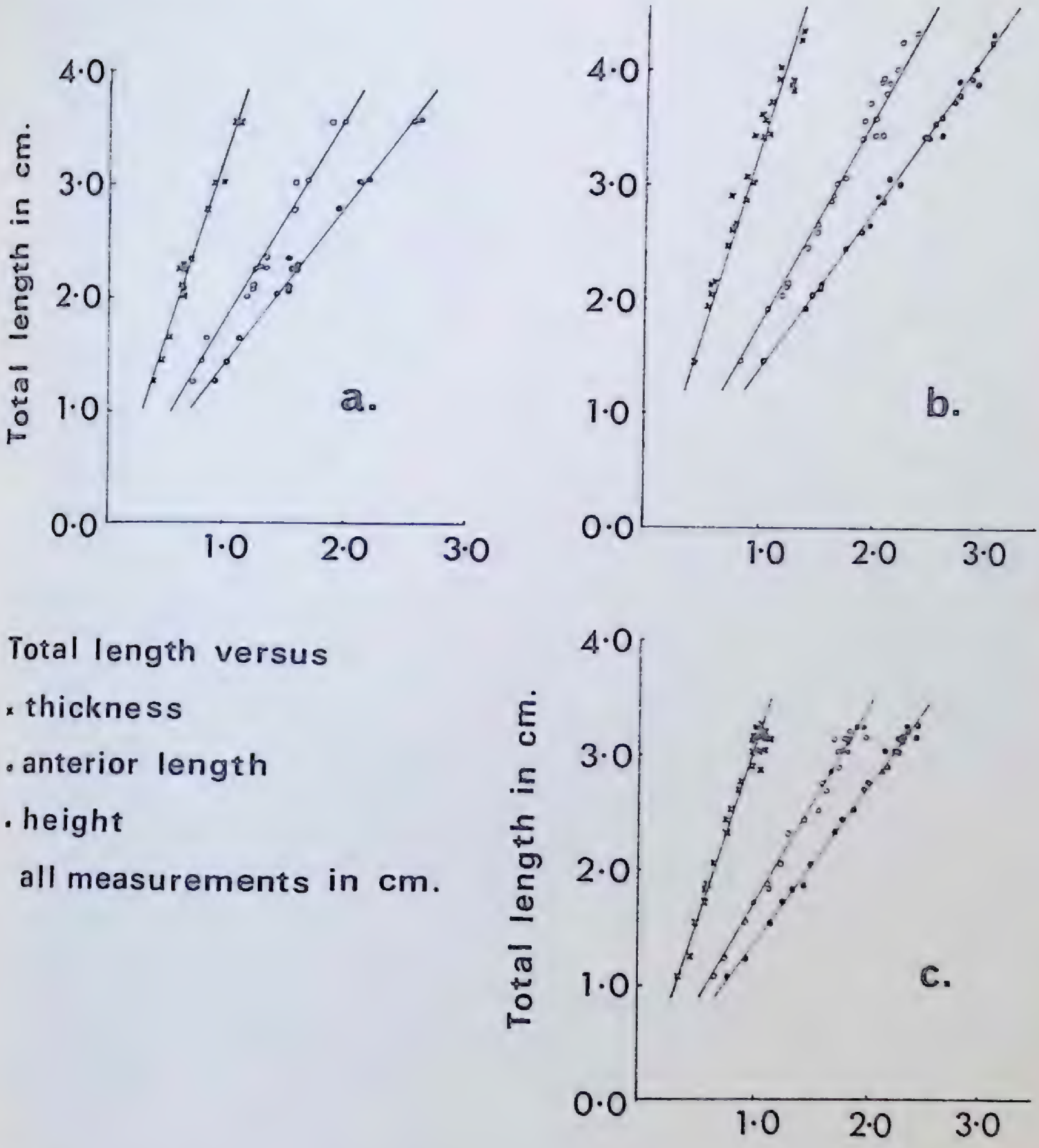

Figure 5 – Plots of total length versus thickness, versus anterior length, and versus height.
a. 15 specimens of *M. calcarea*, inner part of north Stromfjord, western Greenland, Station 17, 56 metres, grey clay with stones; collected 7 December 1911 by 'B.M.'
b. 25 specimens of M. calcarea, north of Moresby Island, Satellite Channel, Vancouver Island, British Columbia, 55 metres, silty sand; collected 27 June 1967 by R.M. Dunnill.
c. 25 specimens of *M. elimata*, north of Moresby Island, Satellite Channel, Vancouver Island, British Columbia; collected 27 June 1957 by R.M. Dunnill.

(b) Soft parts

It is difficult to separate species of *Macoma* on the basis of the soft parts, but both palps and ctenidia seem proportionately larger in the new species than in *M. calcarea* from the type locality of *M. elimata.*

(c) Spermatozoa

Smears were prepared from the testes of specimens of both species, and differences in the shape and size of the spermatozoa were readily apparent (Figure 6). Spermatozoa of *M. elimata* have globose heads, while those of *M. calcarea* have longer, conical heads. The acrosome is larger in *M. calcarea* than in *M. elimata.* Although phase halos around the spermatozoa caused some loss of accuracy in measurement, typical dimensions are given in Table 1.

Table 1 – Dimensions of spermatozoa of *M. calcarea* and *M. elimata*

	*M. calcarea**		
	spermatozoan from a stubby specimen	spermatozoan from an elongate specimen	*M. elimata**
Overall length	–	68.1	65.6
Length of head, acrosome, and middle piece	4.6	4.7	3.5
Length of tail.	–	55.7	57.7
Length of tail end piece	–	6.7	4.5
Diameter of acrosome	1.2	1.1	0.8
Diameter of head	1.9	2.1	2.4
Diameter of middle piece	1.7	1.6	1.3

*All dimensions in μ.

The *M. calcarea* spermatozoa in Figures 6-3a, 6-3b were obtained from the specimens shown in Figures 10-2, 10-3.

(d) Habitat

An area one nautical mile wide and 1.5 nautical miles long off the north end of Moresby Island, in the area of the type locality, was sampled intensively by Dunnill between May and July, 1967, to investigate relationships between the *Macoma* fauna and sediments. The area was surveyed by establishing a grid of 17 stations and by taking 2 hauls per station with a 52.0-litre type Forster Anchor Dredge (Forster 1953). The dredge is estimated to sample an area of 0.69 m^2, penetrating to a maximum depth of approximately 15 centimetres and a mean depth of 7.5 centimetres.

M. calcarea and *M. elimata* were both absent in the 4 stations on shell gravels but were both plentiful at the remaining 13 stations, in sediments including sands, silty sands, clayey sands and sand - silt - clay. *M. calcarea* was absent in 3 of 7 hauls made on sand, but *M. elimata* occurred in all 7. *M. elimata* was present in all 26 hauls at the 13 stations on sediments other than shell gravels; *M. calcarea* was present in only 20. *M. elimata* ranged from 26 - 85 metres, with

maximum density in sand at 29 metres (mean of 2 hauls was 157 specimens per square metre). *M. calcarea* ranged from 29 - 85 metres, with maximum density in silty sand at 80 metres (mean of 2 hauls was 226 specimens per square metre).

Figure 6 – Spermatozoa of *M. calcarea* and *M. elimata.*
1a, b. *M. calcarea,* horizontal white line = 10μ
2a. *M. elimata*, horizontal white line = 5 μ
2b. *M. elimata*, horizontal white line = 10 μ
3a. *M. calcarea*, spermatozoan from a stubby specimen, horizontal white line = 5 μ
3b. *M. calcarea* spermatozoan from an elongate specimen, horizontal white line = 5 μ
All specimens found north of Moresby Island, Satellite Channel, Vancouver Island, British Columbia, 49 metres, silty sand; collected 7 June 1967 by R.M. Dunnill.

II SOME REMARKS ON *MACOMA CALCAREA* (GMELIN 1791)

Figures 2f, 7, 8, 9,10

Synonymy

A synonymy pertinent to the present West American work is presented here.

Tellina calcarea Gmelin 1791: 3236 (38)

= *Tellina lata* Gmelin 1791: 3237 (48) (First reviser probably Dall 1900: 299)

= *Tellina proxima* Sowerby *in* Gray 1839, *ex* Brown MS.: 154, pl. 44, fig. 4

= *Macoma sitkana* Dall 1900: 307, 323, 326 (plate explanation), pl. 4, figs. 6, 7

Type specimens

T. calcarea – This species was based on Chemnitz 1782: 140, pl. 13, fig. 136. It is possible that the original specimen is in the Zoological Museum, University of Copenhagen. Chemnitz' 28.2 mm long specimen is figured here (Figure 7a).

T. lata – Based on Lister 1687: 407 (253). The original specimen measures 47 mm long but is probably lost (Figure 7b).

T. proxima – Dr. Myra Keen, on her last visit to the British Museum (Natural History), was unable to locate this specimen. The description and figure, however, are adequate to identify it as a renaming of *Macoma calcarea* (Gmelin). The original figure is 24 mm long (Figures 7c, d).

M. sitkana – The holotype is a complete specimen measuring 41.6 mm in length, USNM 108656 (Figure 8).

Type localities

T. calcarea – Iceland and the Faeroe Islands

T. lata – 'Norwegian Sea'

T. proxima – 'Arctic Ocean,' presumably off Alaska; collected probably by Capt. F.W. Beechey on the voyage of the *Blossom.*

M. sitkana – Sitka Harbor, Alaska; collected by William H. Dall, in 30 metres.

Range

Throughout the Arctic Ocean, the Bering Sea, along the south coast of Alaska, and the coast of British Columbia, and as far south as Lopez Island, Washington.

DISCUSSION

Specimens of *M. calcarea* from the North Atlantic (western Greenland and eastern Canada) and from the eastern North Pacific (British Columbia and Alaska) are illustrated in Figure 9. There is a similarity between these specimens in shell outline, pallial sinus shape, and shape of the adductor muscle scars.

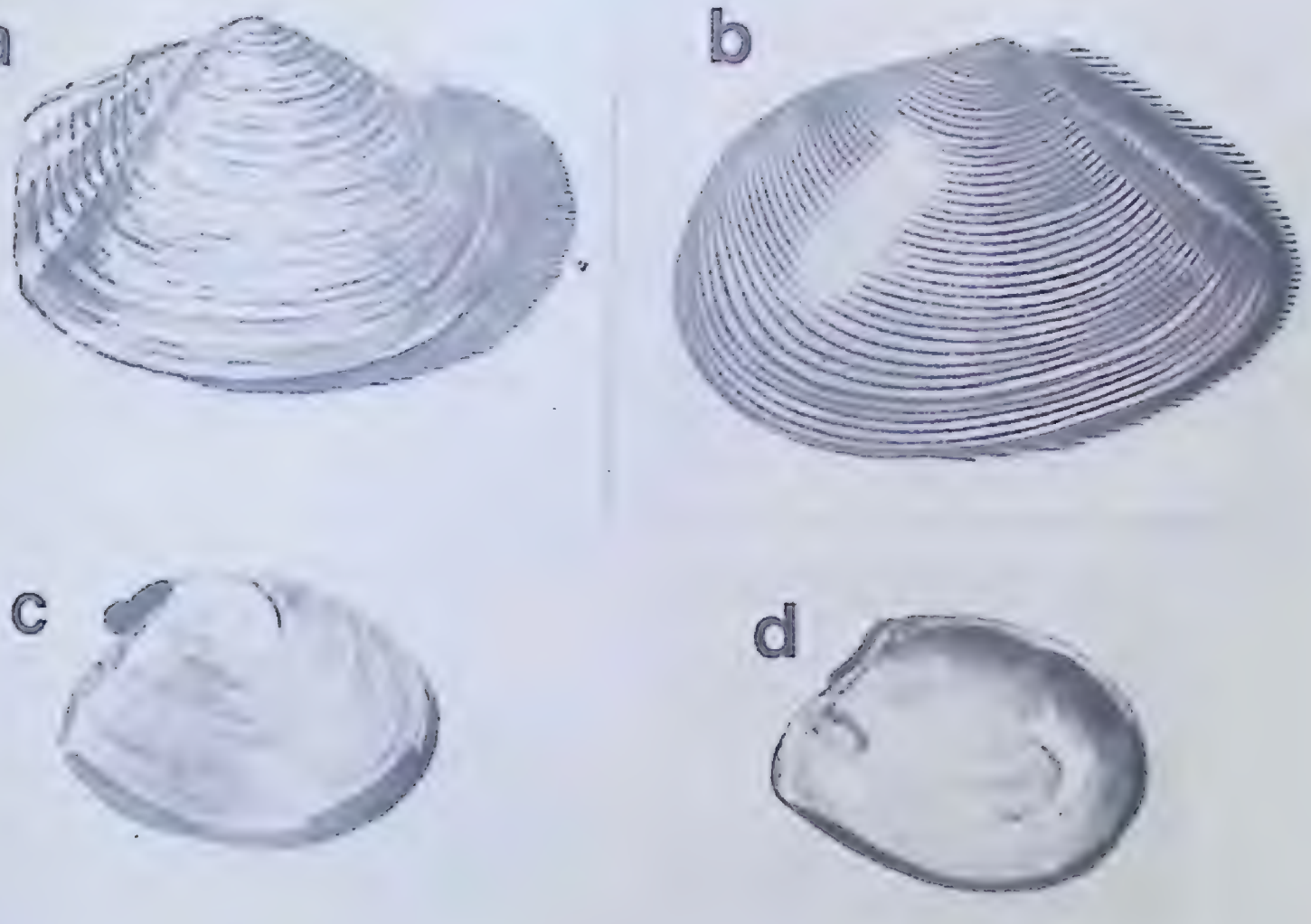

Figure 7 – *Macoma calcarea* (Gmelin 1791)
a. Type of *Tellina calcarea* Gmelin 1791, figure from Chemnitz (1782), plate 13, figure 136. Original drawing measures 28.2 mm.
b. Type of *Tellina lata* Gmelin 1791, figure from Lister (1687), plate 407, figure 235. Original drawing measures 47 mm.
c, d. Type of *Tellina proxima* Sowerby *in* Gray 1839, *ex* Brown MS., plate 44, figure 4, right and left valves. Original drawing measures 24 mm.

Figure 8 – *Macoma calcarea* (Gmelin 1791), holotype of *Macoma sitkana* Dall 1900. Views of inside and outside of both valves and of dorsal surface. Holotype is 41.6 mm in length.

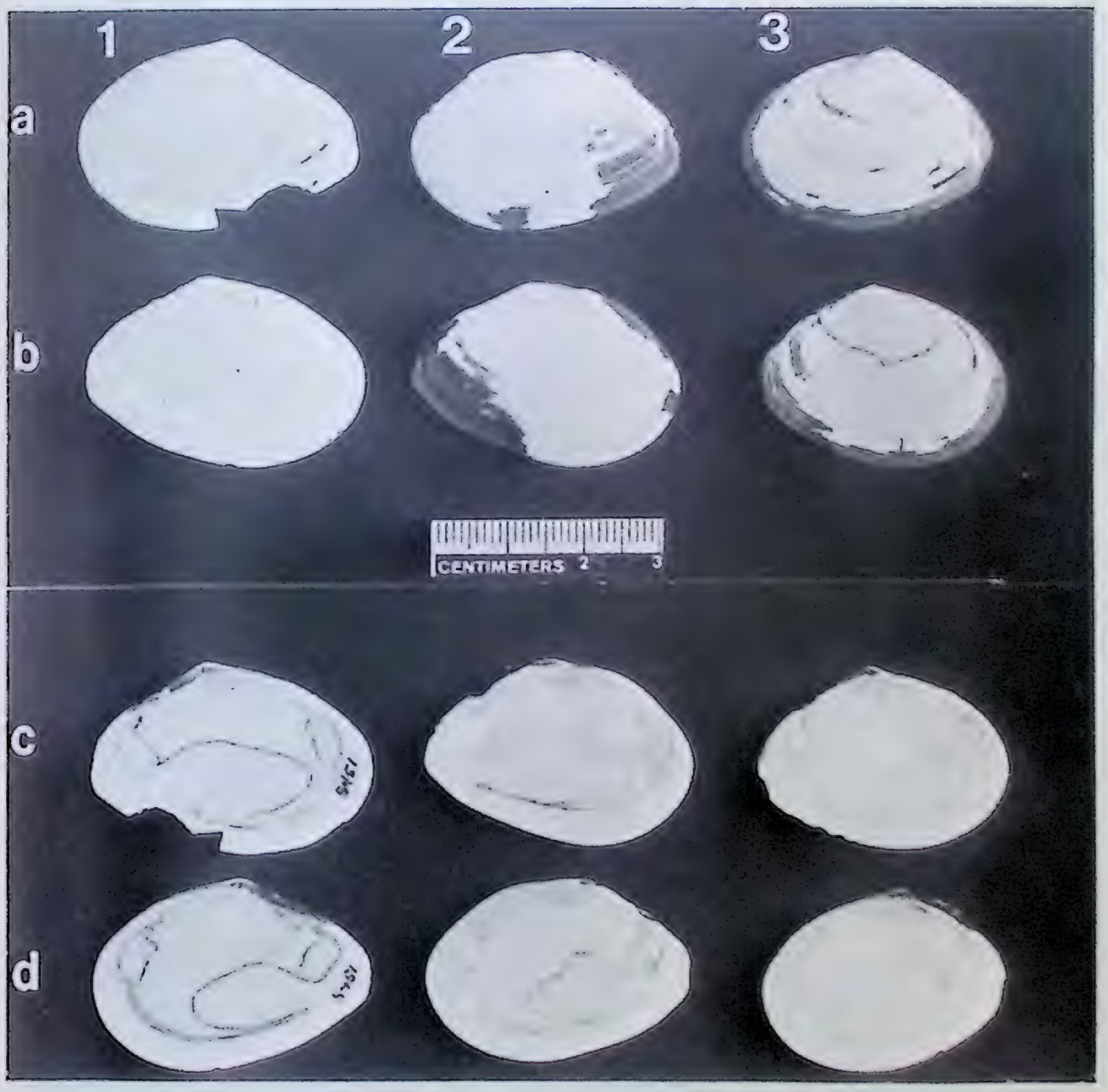

Figure 9 *M. calcarea* Gmelin, outside and inside of both valves.
1a - d. Off Cape Ann gill net docks, Gloucester, Mass., U.S.A., 55 - 110 metres; collected by Dr. A.H. Clarke, Jr., 21 September 1952; National Museum of Canada no. 5451.
2a - d. Inner part of Strømfjord, western Greenland, Station 17, 56 metres, grey clay with stones; collected by 'B.M.,' 7 December 1911.
3a - d. North of Moresby Island, Satellite Channel, Vancouver Island, British Columbia, 55 metres, silty sand; collected by R.M. Dunnill, 27 June 1967.

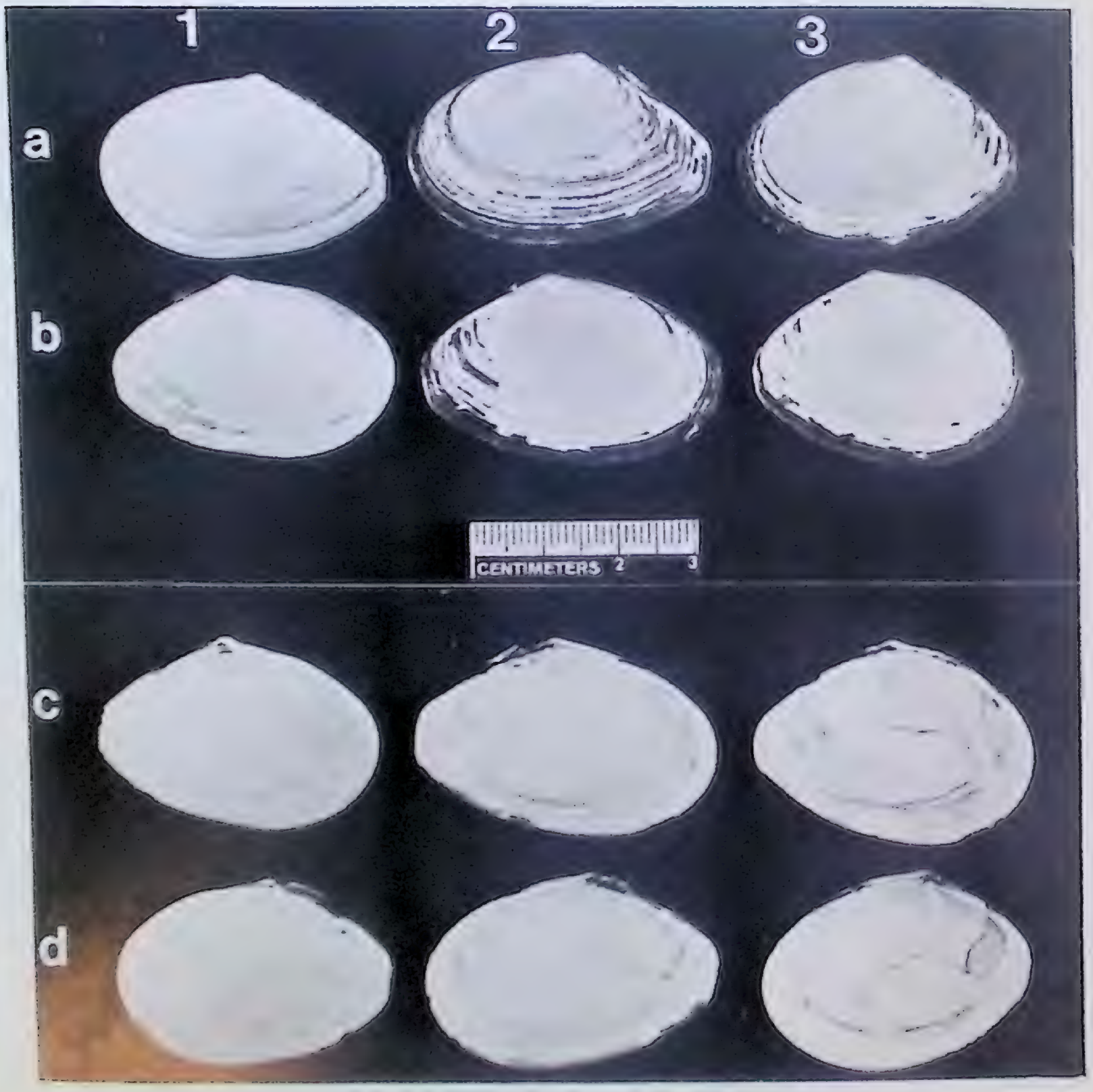

Figure 10 – *M. calcarea* Gmelin, outside and inside of both valves.
1a - d. Elongate specimen. Southwest of King Cove, Cold Bay, Alaska; collected from 47 - 82 metres, 11 August 1964, by 'E.F.' and 'G.R.'; Biological Station. Auke Bay, Alaska, no. AB66-1092.
2a - d. Elongate specimen. North of Moresby Island, Satellite Channel, Vancouver Island, British Columbia, 49 metres, silty sand; collected by R.M. Dunnil, 7 June 1967.
3a - d. Stubby specimen; collection details as for figure 2a - d.

No sperm of Atlantic *M. calcarea* were available, but Dr. K.W. Ockelmann (pers. comm.) comments, "in general, what you [Dunnill and Coan] have identified as *M. calcarea* agrees with our (Atlantic) *M. calcarea,* including the appearance of the sperm."

Variation in some eastern North Pacific specimens

What we have been calling *M. calcarea* in the North Pacific exhibits a greater degree of variation than does *M. calcarea* in the Atlantic. Current knowledge of the geological history of the Arctic Ocean and the Bering Sea suggests that the genus *Macoma* probably had its origin in the North Pacific basin. *Macoma calcarea* and its ancestors have been in this area much longer than in the Atlantic. This longer occupancy, together with the relatively rapidly changing geological complexity of the North Pacific basin, has made possible much speciation. Probably the taxonomic situation is much more complicated than that which is expressed by one world-wide species. For instance, there are some very large specimens in collections from the Bering Sea, much larger than any Atlantic material we have seen, and these may represent stages of hybridization with *M. brota* Dall 1916*a*, or another species.

The resolution of this and other problems involving world-wide Arctic species, which will require statistical surveys of large geographic areas, must consider European nomenclature and include ecological information. Until such surveys are done, it is probably best to be nomenclaturally conservative.

Figures 10-2, 10-3 show variation in shell outline of two specimens of *M. calcarea* from the same station in Satellite Channel, Vancouver Island, British Columbia. The main difference between these specimens is the relatively greater elongation of one specimen (Figure 10-2). Spermatozoa from both specimens (Figures 6-3a, 3b) appear to be identical. Figure 10-1 is a specimen from Cold Bay, Alaska, which, although it is similar in other shell features, is more elongate than either specimen from Satellite Channel. Dall's unique holotype of *M. sitkana* (Figure 8) is also an elongate specimen of *M. calcarea.*

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NATIONAL MUSEUM OF CANADA **NATURAL HISTORY PAPERS**

NOTES ON BIRDS OF THE AMOS REGION, QUEBEC

W. Earl Godfrey

Department of the Secretary of State

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ROGER DUHAMEL, F.R.S.C.
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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

NOTES ON BIRDS OF THE AMOS REGION, QUEBEC

W. EARL GODFREY

The birds of the Clay Belt of Ontario and Quebec have been dealt with by W. John Smith (1957) in an excellent annotated list based on Smith's own field-work in the summers of 1953 and 1954. The list also includes a compilation of data gathered from other sources. For a lucid treatment of the Clay Belt and its botany the reader is referred to W.K.W. Baldwin (1958).

In 1965, with the assistance of Ted Miller, I spent the period June 9 to July 5 collecting, for the National Museum of Canada, ornithological data and specimens in the Amos region, Quebec, which lies in the eastern end of the Clay Belt. Disturbance of the forests is still going on rapidly in the area as a result of lumbering, pulpwood, farming, and mining operations with consequent changes in the avifauna. Some changes have apparently occurred in the eleven-year interval between Smith's work and ours. Supplementary to our observations, I was permitted to examine at La Ferme a well-mounted bird collection, with data, mostly from the Amos region taken and prepared by Brother Clement Larose. That collection contains three species not recorded for the Clay Belt by Smith (1957).

The present list contains 28 species, concerning which data amplificatory or supplementary to those of Smith (1957) are presented. Additions to Smith's list are the Yellow Rail, Short-eared Owl, Boreal Owl, Marbled Godwit, Parasitic Jaeger, Ring-billed Gull, Le Conte's Sparrow, and Clay-colored Sparrow.

In most parts of Canada pure stands of jack pine (*Pinus banksiana*) are not notable, in my experience, for a great variety of large numbers of bird inhabitants. In the Amos region, however, I gained the distinct impression that a relatively wider variety and larger numbers of birds than usual favoured both young and medium-sized pure jack pine forest, although I have no comparable figures to support it. Some evidence of this is mentioned below. Jack pine in pure stands, often extensive, is found on sandy eskers, moraines, and outwash plains of the region.

La Ferme, frequently mentioned below, is an agricultural school some four miles west of Amos. I am deeply grateful to Les Clercs de St. Viateur for their hospitality and helpfulness during our stay at La Ferme.

In the observations recorded in this paper, a number in parentheses following a date indicates the number of individuals observed on that date.

Horned Grebe. *Podiceps auritus* (Linnaeus). – There is a mounted specimen taken at La Ferme, October 28, 1955, in the Larose collection. Smith (1957) mentions the species as a transient at Timmins, Ontario.

American Widgeon. *Mareca americana* (Gmelin). – Nesting in the Clay Belt was established by the presence of a female with five downy young, which I

watched closely on June 27 in *Eleocharis palustris* and *Carex aquatalis* vegetation on the west shore of Robertson Lake. Later an adult male was observed on the same lake.

Greater Scaup. *Aythya marila* (Linnaeus). – A mounted specimen in the Larose collection taken at Amos on May 28, 1955, confirms reports of it as a transient given to Smith (1957).

Willow Ptarmigan. *Lagopus lagopus* (Linnaeus). – Smith (1957) mentions its occurrence in severe winters at Cochrane and Elsas, Ontario. The Larose collection contains a specimen taken at La Ferme, Quebec, on December 23, 1959.

Yellow Rail. *Coturnicops noveboracensis* (Gmelin). – A mounted specimen in the Larose collection was collected on August 7, 1959.

Short-eared Owl. *Asio flammeus* (Pontoppidan). – I observed one on June 14 and probably the same individual again on June 24 at Ste. Gertrude.

Boreal Owl. *Aegolius funereus* (Linnaeus). – A mounted specimen in the Larose collection was taken at La Ferme on October 27, 1956.

American Woodcock. *Philohela minor* (Gmelin). – Smith (1957) regards it as being very rare and gave sight records reported to him from Timmins, Cochrane, and Gogama. A specimen in the Larose collection was taken at Desmeloizes, Quebec, on July 15, 1956. We observed none.

Common Snipe. *Capella gallinago* (Linnaeus). – Not uncommon in the Amos region where I observed it on June 10 (2 birds), 11(3), 14(1), 15(2), 16(1), 18(1), 19(2), 20(1), 22(1), 23(1), 26(2), 29(2), July 1(1), 3(1).

Marbled Godwit. *Limosa fedoa* (Linnaeus). – A fine mounted specimen in the Larose collection was taken by Larose at La Ferme on May 3, 1953, the first record for the Clay Belt.

Parasitic Jaeger. *Stercorarius parasiticus* (Linnaeus). – One was collected at La Ferme in late July, 1965, and is in the museum of Collège d'Amos (Fernand Miron *in litt.*, November 14, 1965).

Ring-billed Gull. *Larus delawarensis* Ord. – I closely observed a one-year-old individual on June 28, 1965, as it flew about the Harricanaw River, near Amos. Not previously reported from the Clay Belt.

Black Tern. *Chlidonias niger* (Linnaeus). – Smith (1957) did not encounter it east of Lake Abitibi, Quebec. In 1965, I observed eight near La Ferme on June 13; three on July 4 at Taschereau, and two in a marsh 4 miles east of Taschereau. This species may be increasing in the Clay Belt.

Chimney Swift. *Chaetura pelagica* (Linnaeus). – There is a specimen in the Larose collection taken at La Ferme on June 10, 1951. In 1965, the writer saw two in flight at Amos on July 2. Smith (1957) gives several additional records for other localities.

Yellow-bellied Flycatcher. *Empidonax flaviventris* (Baird and Baird). – Quite common in the Amos region where I recorded the following observations: June 10(7), 11(7), 12(6), 14(4), 15(6), 16(3), 17(8), 18(6), 19(7), 21(6), 22(5), 23(8), 24(6), 25(5), 26(3), 29(5), 30(5); July 1(2), 2(2), 3(2), 4(2), 5(3). Although most were in damp, shady coniferous and mixed woods, they occurred also in dry sandy jack pine woodlands on eskers. Specimens collected: 3 ad. males, 2 ad. females, June 10 - 23.

Olive-sided Flycatcher. *Nuttallornis borealis* (Swainson). – Like Smith (1957) I found this flycatcher scarce. Two near Chicobi Lake on June 17 were my only observations.

Cliff Swallow. *Petrochelidon pyrrhonota* (Vieillot). – In 1965, we found small nesting colonies at Villemontel, Launay, and Amos.

Swainson's Thrush. *Hylocichla ustulata swainsoni* (Tschudi). – As Smith (1957) surmised, this species is common in the Amos region where in 1965 we observed up to 16 in a day. Specimens taken: 4 ad. males, 1 ad. female, June 10 - 29, 1965.

Chestnut-sided Warbler. *Dendroica pensylvanica* (Linnaeus). – This species may have increased numerically in the region recently. Snyder (1928) took only one specimen at Lake Abitibi, Ontario. Smith (1957) did not encounter it north of New Liskeard, Ontario, although he was given a sight record for Cochrane. In 1965, I found it not uncommon in the country between Amos and Taschereau and north nearly to Chicobi Lake and to Lake Berry, 11 miles north of Launay Station. Specimens collected: 6 ad. males, June 10 - July 6.

Palm Warbler. *Dendroica palmarum palmarum* ⟷ *hypochrysea*. – Uncommon. Only 12 specimens were noted, all but one of which were in small- to medium-sized jack pines. Specimens collected: 3 ad. males, 2 ad. females, June 14 - July 3. These five specimens are almost exactly intermediate between the two races and show that the Amos region is an area of intergradation.

Ovenbird. *Seiurus aurocapillus aurocapillus* (Linnaeus). – Although most occupied, as usual, hardwoods or mixed woods, the species was often found also in pure stands of jack pine. On June 9, one was noted in dense white spruce woods with a thick moss carpet! Specimen collected: 1 ad. male, June 10.

Connecticut Warbler. *Oporornis agilis* (Wilson). – Three individuals, all singing males, were observed. One was in a black spruce bog. The two others were in sparse, dry, immature jack pine. In my experience, this is an unusual habitat for the species. Specimen collected: 1 ad. male, 6 miles north of Villemontel, June 19, 1965.

Wilson's Warbler. *Wilsonia pusilla pusilla* (Wilson). – We found it much commoner than did Smith (1957), who reported only two. We recorded it on June 15(6), 16(2), 17(6), 18(5), 21(1), 22(3), 25(3), 26(4), 27(1), 28(4), 29(3); July 2(1), 3(3), and 5(3). Specimens collected: 4 ad. males, 1 ad. female, June 15 - 28, 1965.

Bobolink. *Dolichonyx oryzivorus* (Linnaeus). – Smith (1957) gave evidence that this species was becoming established at various points in the Clay Belt. At

La Ferme, however, it was still scarce in 1953 and 1954, for he did not observe it there, although its previous presence was reported to him. In 1965 I counted 14 individuals at La Ferme on June 20, obviously a substantial increase; five at Taschereau on June 27; and one near Villemontel on June 16. Specimen collected: 1 ad. male, June 28.

Brown-headed Cowbird. *Molothrus ater ater* (Boddaert). – This is another species that appears to have increased since Smith's (1957) observations. In 1965 we saw as many as seven in a day at La Ferme (also a young Cowbird being fed by a Song Sparrow). The species was observed also at Davy Lake and Villemontel. Specimen collected: 1 ad. male, July 1.

Le Conte's Sparrow. *Passerherbulus caudacutus* (Latham). – This obscure species was observed by the writer at several points: a singing male 8 miles south of Villemontel on June 19 in a small moist grass-sedge meadow, two in a damp grassy field on the east side of La Ferme on July 4, one in a moist hay field near Lac George at La Ferme on July 5, two in a sedge meadow 1½ miles north of Villemontel. Specimens collected: 2 ad. males June 19 - July 5, both in breeding condition. The Le Conte's Sparrow was not recorded by Smith (1957) in the Clay Belt, nor was it detected by Snyder's (1928) party at Lake Abitibi, Ontario. Because of a seemingly isolated instance of nesting at St. Fulgence, far to the east, on the Saguenay River (Boulva and Browne 1964), I made a particular search for the species in the Amos region with the above results. It seems probable that a sparse population of this easily overlooked species forms a more or less continuous breeding range eastward to the Saguenay River.

Clay-colored Sparrow. *Spizella pallida* (Swainson). – One of the surprises of the trip was a silent male Clay-colored Sparrow I collected in alder-willow shrubbery 1½ miles northwest of Villemontel on July 5. This record is the only one for the Clay Belt, but since the species has recently extended its breeding range eastward to Ottawa (Godfrey 1966), it is possible that it breeds sparsely in the Clay Belt as well.

Swamp Sparrow. *Melospiza georgiana ericrypta* (Oberholser). – A substantial series of breeding adults collected in the Amos region contains several somewhat darker individuals similar to a series from James Bay examined by Todd (1963) and Godfrey (1949). Such extremes are to be found in other populations of *ericrypta,* and, in my opinion, the series as a whole is referable to that subspecies. More material is needed, however, from James Bay. Specimens collected: 14 ad. males, 2 ad. females, June 14 - 30.

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NATIONAL MUSEUM OF CANADA NATURAL HISTORY PAPERS

Recent Species of the Genus *Macoma* (Pelecypoda) in British Columbia

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RECENT SPECIES OF THE GENUS MACOMA (PELECYPODA) IN BRITISH COLUMBIA

R.M. Dunnill* and D.V. Ellis*

INTRODUCTION

The genus *Macoma* (Pelecypoda) is widely distributed on marine sediments in the northern hemisphere. It has considerable ecologic and zoogeographic interest, particularly since it is one of the genera on which Thorson (1957) based his concept of parallel level-bottom communities.

The literature on the genus records a considerably greater number of species in the North Pacific than in the Arctic or Atlantic. Abbott (1954), Bernard (1967), Burch (1946), Dall (1921), Grant and Gale (1931), Ockelmann (1958), Oldroyd (1924), and Whiteaves (1901) collectively record 28 recent species, sub-species, or 'varieties' in the eastern North Pacific compared to 10 in the Arctic and 10 in the North Atlantic. The eastern North Pacific *Macomas* listed are as follows:

M. alaskana Dall
M. astori Dall
M. balthica (L.)
M. brota Dall
M. brota lipara Dall
M. calcarea (Gmelin)
M. carlottensis Whiteaves
M. expansa Carpenter
M. incongrua (von Martens)
M. inconspicua (Broderip and Sowerby)
M. indentata Carpenter
M. indentata tenuirostris Dall
M. inflatula Dall
M. inquinata (Deshayes)
M. inquinata arnheimi Dall
M. irus (Hanley)
M. kelseyi Dall
M. krausei Dall
M. leptonoidea Dall
M. liotricha Dall

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M. middendorffii Dall
M. moesta (Deshayes)
M. nasuta (Conrad)
M. planiuscula Grant and Gale
M. quadrana Dall
M. secta (Conrad)
M. sitkana Dall
M. yoldiformis Carpenter

The list is considerably shortened when probable synonyms are taken out. The references cited indicate the following species occur in British Columbia waters (synonyms are listed):

M. alaskana Dall
M. brota Dall
M. brota lipara Dall (called by Dall a sub-species of *M. brota*, this is a distinct species, *M. lipara* Dall. *M. astori* Dall may be an earlier name)
M. calcarea (Gmelin)
M. carlottensis Whiteaves (=*M. inflatula* Dall = *M. quadrana* Dall)
M. expansa Carpenter
M. incongrua (von Martens)
M. inconspicua (Broderip and Sowerby) (formerly called *M. balthica* (L.), a separate Atlantic species)
M. indentata Carpenter
M. inquinata (Deshayes) (probably = *M. inquinata arnheimi* Dall and formerly called *M. irus* (Hanley), a separate Japanese species)
M. liotricha Dall (may = *M. expansa* Carpenter)
M. moesta (Deshayes) (possibly *M. krausei* Dall is a synonym)
M. nasuta (Conrad) (possibly *M. kelseyi* Dall is a synonym)
M. planiuscula Grant and Gale
M. secta (Conrad)
M. yoldiformis Carpenter

Initiation of a marine sediment-biological research program at the University of Victoria in 1964 prompted an investigation to determine species of *Macoma* actually present in British Columbia. Collections made in the Strait of Georgia and adjacent inlets, as part of the general program, were examined for specimens of *Macoma*. Additional specimens were then obtained from F. Bernard and Dr. D. Quayle (Fisheries Research Board of Canada, Biological Station, Nanaimo, British Columbia), Dr. A. Clarke, Jr. (National Museum of Canada), and Dr. I. McT. Cowan (University of British Columbia). Further collections, designed in part for an ecological investigation, were made by R.M. Dunnill. Ships and launches were made available for the investigations by the Defence Research Board, the Department of Energy, Mines, and Resources, and the Department of Transport.

Examination of several hundred specimens revealed a new species, *M. elimata* Dunnill and Coan (in press), and confirmed 12 additional species for British

Columbia. Descriptions are provided here for populations of the species in the area of the investigations. The species found are as follows:

M. alaskana Dall
M. brota Dall
M. calcarea (Gmelin) (= *M. sitkana* Dall)
M. carlottensis Whiteaves (= *M. inflatula* Dall = *M. quadrana* Dall)
M. elimata Dunnill and Coan
M. expansa Carpenter (possibly may include *M. liotricha* Dall)
M. incongrua (von Martens)
M. inconspicua (Broderip and Sowerby)
M. inquinata (Deshayes) (= *M. inquinata arnheimi* Dall)
M. lipara Dall (*M. astori* Dall may be an older name)
M. nasuta (Conrad) (possibly = *M. kelseyi* Dall)
M. secta (Conrad)
M. yoldiformis Carpenter

The following species may also occur in British Columbia:

M. indentata Carpenter
M. moesta (Deshayes)
M. planiuscula Grant and Gale

The authors wish to express their appreciation for the support provided by the organizations mentioned above, for materials and information very generously supplied by F. Bernard, A. Clarke, E.V. Coan, I. McT. Cowan, and D. Quayle, and for financial support from the National Museum of Canada. They are also indebted to D. Thorndick for his generous help with the photography.

Measurements referred to in the paper are shown in Figure 1. Collection initials are shown below:

NMC – National Museum of Canada
FRB – Fisheries Research Board of Canada
USNM – United States National Museum
RD – R. Dunnill
UVIC – University of Victoria

Other abbreviations are:

LV – left valve
RV – right valve

Descriptive terminology follows that of Arnold (1965). Sediments are named after the system of Shepard (1954), except where the descriptive term is given in quotation marks.

Measuring Procedures

All measurements were made with vernier calipers graduated in millimetres. Valve length refers to the greatest length that could be obtained parallel to a straight line across the tops of the widest parts of the adductor scars (*see* Figure 1).

Valve height, anterior length, and the distance from posterior margin to anterior-most extension of the pallial sinus were measured in reference to the same line.

Generic Description

Genus *Macoma* Leach, 1819.

Type (by monotypy) *Macoma tenera* Leach (= *Tellina calcarea* Gmelin). No lateral teeth. Two cardinal teeth in each valve, one of each pair usually stout and bifid, the other single and often fragile. Usually twisted to the right posteriorly, often strongly. Sculpture usually of fine concentric growth lines only. Generally not much inflated. Outline variable from elongate-ovate to sub-circular. Pallial sinuses generally larger in the left valve than the right.

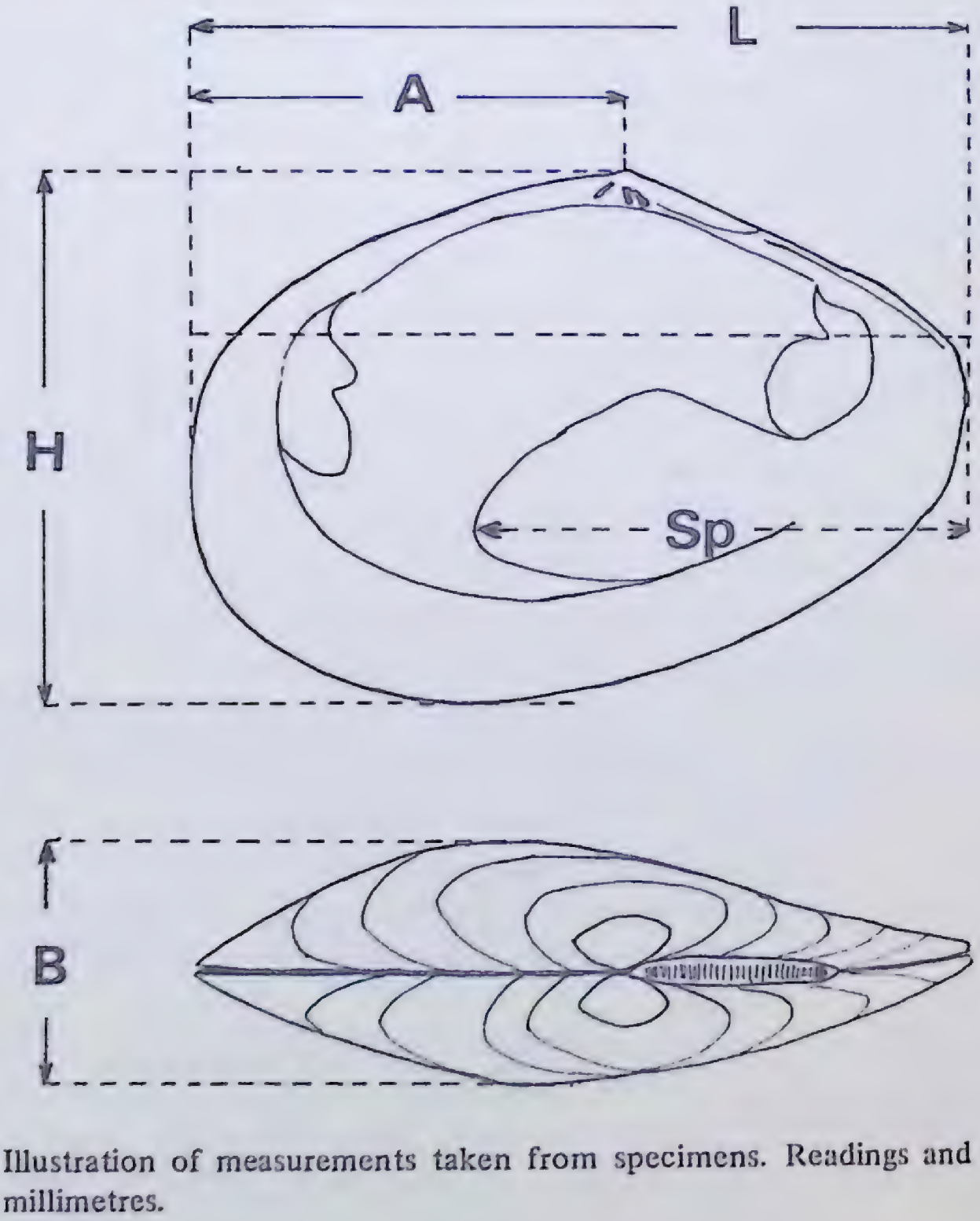

Figure 1 – Illustration of measurements taken from specimens. Readings and figure scales in millimetres.

Key to the British Columbia Macoma species

1 Pallial sinus in left valve reaches and joins anterior adductor scar well above its base *M. nasuta*

Pallial sinus in left valve does not join anterior adductor scar well above its base but may reach it near its base 2

2(1) Periostracum glazed or highly polished, usually transparent 3

Periostracum not glazed or highly polished (but may be shiny); periostracum opaque or transparent 6

3(2) Ligament short, noticeably wide and prominent; valves white and very unequal. Right valve flattened and less convex than left; oblique ray(s) radiate from umbo in posterior end of left valve

M. secta

Ligament not noticeably wide; valves ovate or sub-ovate, nearly equivalved 4

4(3) Anterior end elongated, about two-thirds of total length 5
Anterior end not elongated noticeably; shell thin and moderately inflated; posterior end drawn out into a rounded beak and longer than anterior end. Dorsal slope somewhat straight

M. expansa

5(4) Elongate-ovate, almost equally rounded at both ends but anterior curve has larger radius than posterior curve; notched for ligament

M. yoldiformis

Ovate anteriorly but wedge-shaped posteriorly; not notched for ligament

M. alaskana

6(2) Valves not inflated relative to size of shell 7
Valves somewhat inflated relative to size of shell 11

7(6) Shell medium sized (to about 3.5 centimetres in length), posterior dorsal slope bevelled, forming an obvious, sharply incised, flattened or slightly concave escutcheon

M. elimata

Posterior dorsal slope not bevelled, no obvious elongated, flattened or concave escutcheon 8

8(7) Pallial sinuses looped and confluent with pallial line well back from anteriormost extent 9
Pallial sinuses confluent with pallial line at a near right angle and near anteriormost extent. Shell small, outline circular to sub-ovate; white, pink or flushed with pink on inside, outside, or on both surfaces

M. inconspicua

9(8) Posterior ends in a fairly narrow truncation; ratio of length/height variable, i.e. some specimens are noticeably more elongate than others

M. calcarea

Posterior ends in a noticeably broad truncation or does not end in a narrow truncation 10

10(9) Posterior roundly truncated, shell white or straw-yellow and thick in some; shell may be shiny; periostracum usually very much eroded

M. lipara

Posterior margin has an abrupt change in slope; ventral margin may have a slight sinuosity; posterior end broadly truncated, perpendicularly; usually retains a fair proportion of its periostracum; periostracum muddy-green and flaky

M. brota

11(6) Shell small (generally less than 2.5 centimetres in length), inflated, sub-ovate, fragile; wedge-shaped posteriorly, tending to become rostrate in larger specimens; pallial sinus looped and confluent well back from anteriormost extent; interior white with a low shine; sometimes iridescent

M. carlottensis

Shell to medium or large sized, not fragile; pallial sinus confluent near anteriormost extent but may be slightly recurved 12

12(11) Shell to medium sized (3 to 4 centimetres in length), roughly circular, height almost equals length; fine but well defined concentric growth lines

M. incongrua

Shell to large sized, ovate or sub-ovate, obviously not circular; flaky, fibrous, olive-green periostracum over a chalky, dull white shell

M. inquinata

Macoma alaskana Dall 1900, Proc. U.S. Nat. Mus., 23: 323.

Type Locality: Lituya Bay, Alaska.

Specimens Examined

14 from Narvaez Bay, Saturna Island, Strait of Georgia, British Columbia, October 1966, 100 fathoms – RD.

1 from Kishushan Light, Strait of Georgia, British Columbia, October 1966, 55 fathoms – NMC 40257.

1 from Mill Bay, Saanich Inlet, Vancouver Island, British Columbia (dead specimen), October 1966, about 10 fathoms – RD.

2 from the north end of Moresby Island, near Victoria, Vancouver Island, British Columbia, October 1966, 27 fathoms – RD.

Measurements

Size (cm)	No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
1.00 - 2.00	12 LV	1.42	0.89	0.39	0.95	1.06	0.62	0.27	0.67	0.75
	RV	1.41	0.89		0.94	0.89	0.63		0.67	0.63
2.00 - 3.00	6 LV	2.21	1.40	0.59	1.41	1.68	0.63	0.26	0.64	0.76
	RV	2.20	1.40		1.41	1.30	0.63		0.64	0.59

General Description – Figures 2, 2a - d; 9i

One of the smallest of North American west coast *Macoma* species, *M. alaskana* reaches a length of a little over 2.5 centimetres. The shell is somewhat compressed and inequilateral, the anterior portion almost twice as long as the posterior portion. The valves are white, with a beautifully glazed, thin, faintly tinted periostracum, darker at the posterior margin. The beaks are slightly prominent and situated about two-thirds of the way from the anterior end. The anterior margin is arcuate, the posterior cuneate, the posterior dorsal margin descending rapidly from the beaks and meeting the rising ventral margin in a blunt point. Feeble concentric growth lines are the only shell ornamentation. The ligament is relatively long and narrow.

The interior is bluish white, polished and sometimes iridescent. The pallial sinus is longest in the left valve, extending nearly to the anterior adductor scar. The angle of divergence of the two cardinal teeth in each valve is such that the teeth form roughly an isosceles triangle.

Unique Species Characteristics

M. alaskana is distinguished from other *Macoma* species by the relatively great length of the anterior portion of the shell compared to the length of the posterior. It bears some resemblance to *M. yoldiformis* Carpenter, but *M. yoldiformis* is ovate, while *M. alaskana* is wedge-shaped posteriorly. *M. alaskana* resembles *Tellina modesta* Carpenter and *T. buttoni* Dall, but *Tellina* has lateral teeth, absent in *Macoma*. *M. alaskana* resembles juvenile specimens of *M. calcarea* (Gmelin), but,

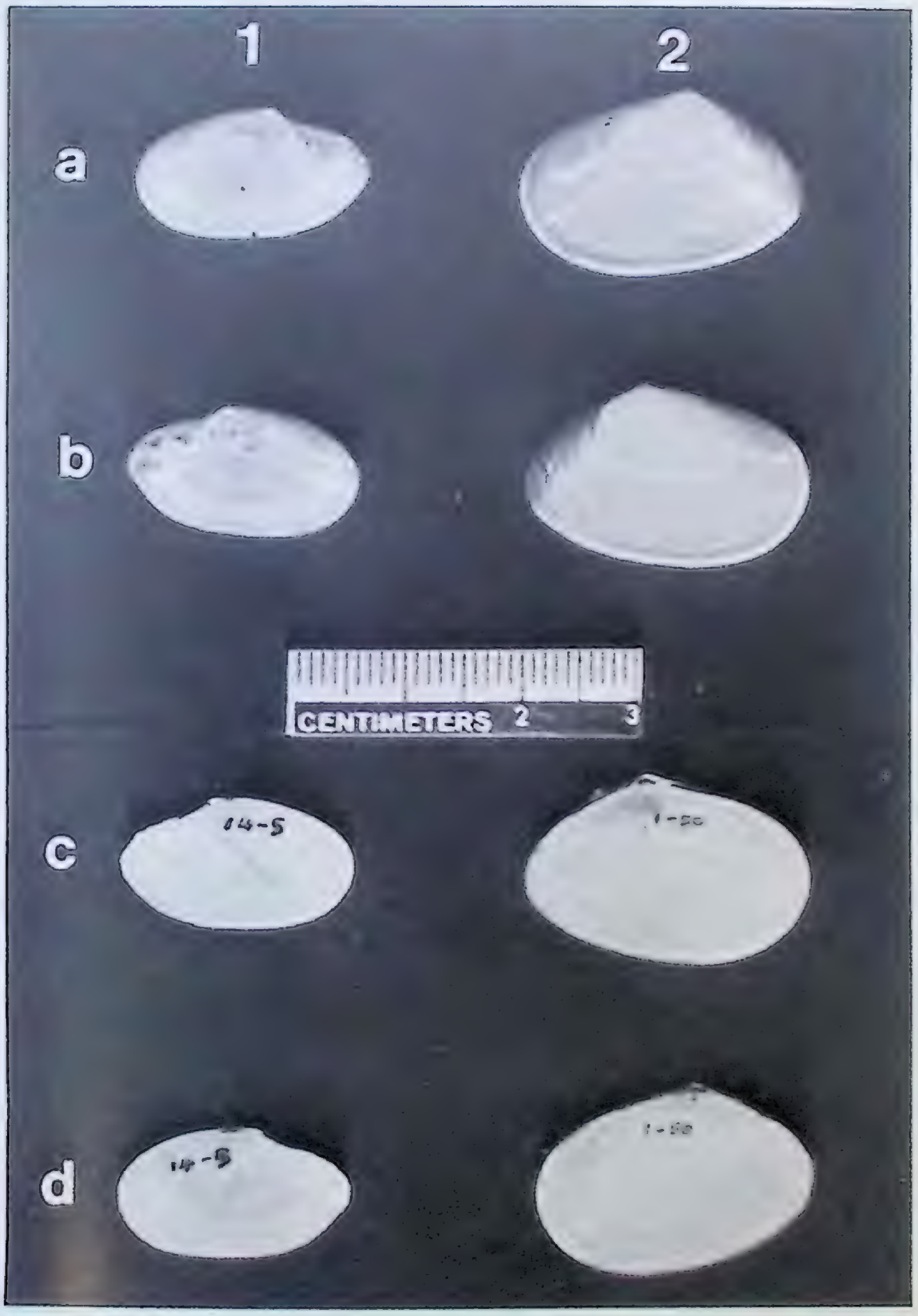

Figure 2 – 1a - d. *M. yoldiformis* Carpenter
2a - d. *M. alaskana* Dall

when dry, the periostracum is glazed and transparent in *M. alaskana* and dull and opaque in *M. calcarea*. *M. alaskana* is relatively longer in the anterior portion than *M. calcarea*.

Distribution and Habitat

According to Bernard (1967: 26), *M. alaskana* ranges from 48 - 60°N and from 20 - 80 fathoms. However, it was dredged from 14 - 35 fathoms off Moresby Island, near Victoria, Vancouver Island, British Columbia, from sand, silty-sand and clayey-sand and from 100 fathoms at the mouth of Narvaez Bay, Saturna Island.

Macoma brota Dall 1916, Proc. U.S. Nat. Mus., 52: 413.

Type Locality: Bering Strait, Alaska.
Synonym: Tellina edentula Broderip and Sowerby

Note

"Dall renamed *T. edentula* Broderip and Sowerby because it was a homonym of *T. edentula* Spengler, 1798, p. 96-97 (no. 24). (Over det teskallende slaegt Tellinerne. Skiv. Nat. Selsk. Copenhagen 4 (2): 67-127; pl. 12). The type specimen remains the same, that of Broderip and Sowerby, now lost (fide Keen and Tebble). The identity is clear, so a neotype is not needed. The specimen from the U.S. National Museum figured by Oldroyd as type is not the type specimen" (E.V. Coan, pers. comm.).

Specimens Examined

32 from the north end of Moresby Island, near Victoria, Vancouver Island, British Columbia, October 1966, about 30 fathoms – RD.

1 intact specimen and 3 odd valves from north of Unimak Island, Alaska USNM 212910 and 204817.

Measurements

Size (cm)	No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Moresby Island										
2.00 - 4.00	18 LV	3.13	2.34	1.03	1.89	2.30	0.75	0.33	0.60	0.73
	RV	3.13	2.34		1.90	1.91	0.75		0.60	0.61
4.00 - 6.00	14 LV	4.52	3.39	1.53	2.70	3.33	0.75	0.34	0.60	0.74
	RV	4.50	3.40		2.70	2.71	0.75		0.60	0.60
N of Unimak Island										
6.00 - 8.00	1 LV	6.50	4.89	—	3.75	4.57	0.75	—	0.58	0.70
	3 odd RV valves	6.52	4.96		4.08	3.87	0.76		0.62	0.59

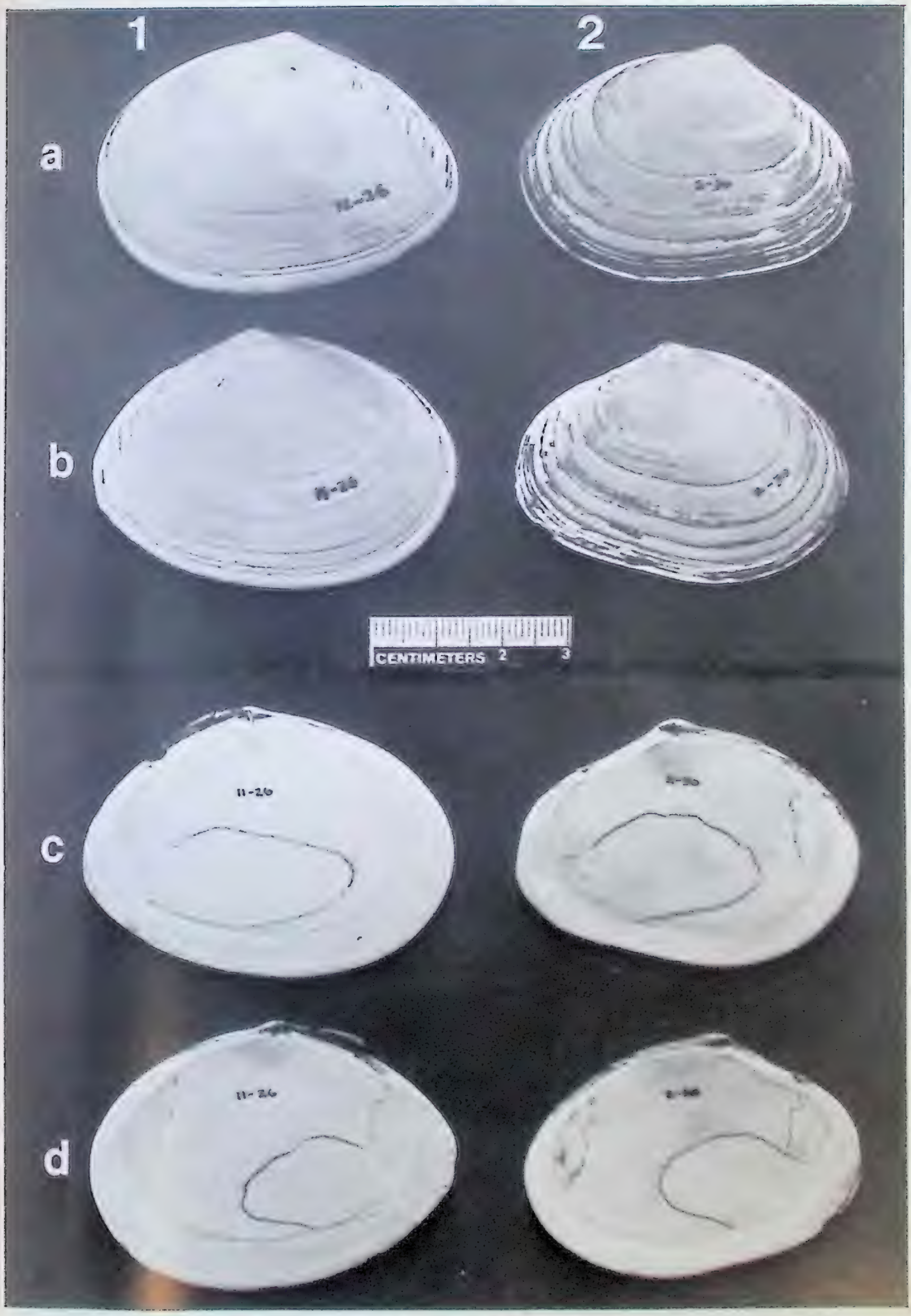

Figure 3 – 1a - d. *M. lipara* Dall
2a - d. *M. brota* Dall

Size ranges (lengths) were 2.16 - 5.56 centimetres for the Vancouver Island specimens and 6.22 - 6.78 centimetres for those from Alaska. The Vancouver Island specimens were dredged up alive, but those from Alaska were dead and had Bryozoon colonies on the insides of the valves or had been perforated by predatory Gastropoda.

General Description – Figures 3, 2a - d; 9a

M. brota, one of the largest of North American west coast *Macoma* species, is moderately inflated and inequilateral, with prominent umbos situated about three-fifths of the distance back from the anterior to the posterior extremity. The anterior is ovate, but posteriorly the dorsal margin is straight and steeply sloping until abruptly cut off by a broad perpendicular truncation. Ventrally, the larger specimens may become slightly sinuous. The shell is variable in thickness but not fragile and is drab white under an opaque, grey-green, muddy appearing periostracum, much of which has flaked off in the larger specimens. Irregular concentric growth lines are the only ornamentation. There is a slight gape and a strong flexure to the right at the posterior end. The long narrow ligament is partially embedded and seated on a strong callus.

The interior is porcellanous white to bluish-white with a low polish and is sometimes iridescent. The pallial sinuses, fairly high and considerably longer in the left valve than in the right, are confluent with the pallial line far back from their anteriormost extent, roughly beneath the umbos. There are two cardinal teeth in each valve, the right posterior and left anterior bifid and the others laminar.

Unique Species Characteristics

See *M. calcarea* (Gmelin).

Note

Oldroyd's illustration of *M. calcarea* is *M. brota* (Oldroyd, 1924, pl. 42, fig. 5).

Distribution and Habitat

According to Bernard (1967: 27) *M. brota* occurs from 48 - 64°N and from 30 - 80 fathoms. However, he has considered *M. lipara* Dall a synonym of *M. brota* and included both species in his ranges. *M. brota* was dredged off Moresby Island, near Victoria, British Columbia, from sands, clayey-sands, silty-sands, and sand-silt-clay in 16 - 45 fathoms, reaching a maximum density of 75 specimens/metre^2 in 40 fathoms, on sand-silt-clay, at the same station that *M. lipara* Dall and *M. incongrua* (von Martens) reached their maximum densities.

Macoma calcarea (Gmelin) 1792, Syst. Nat., 7: 3236.

Type Locality: Iceland or Faroe Islands.

Specimens Examined

10 from north end of Moresby Island, near Victoria, Vancouver Island, British Columbia, October 1966, about 30 fathoms – RD.

15 from Gilford Island, Queen Charlotte Strait, British Columbia, April 1966, 22 - 30 fathoms – FRB.

3 near Nunivak Island, Bering Sea, 35 fathoms – USNM 108666.

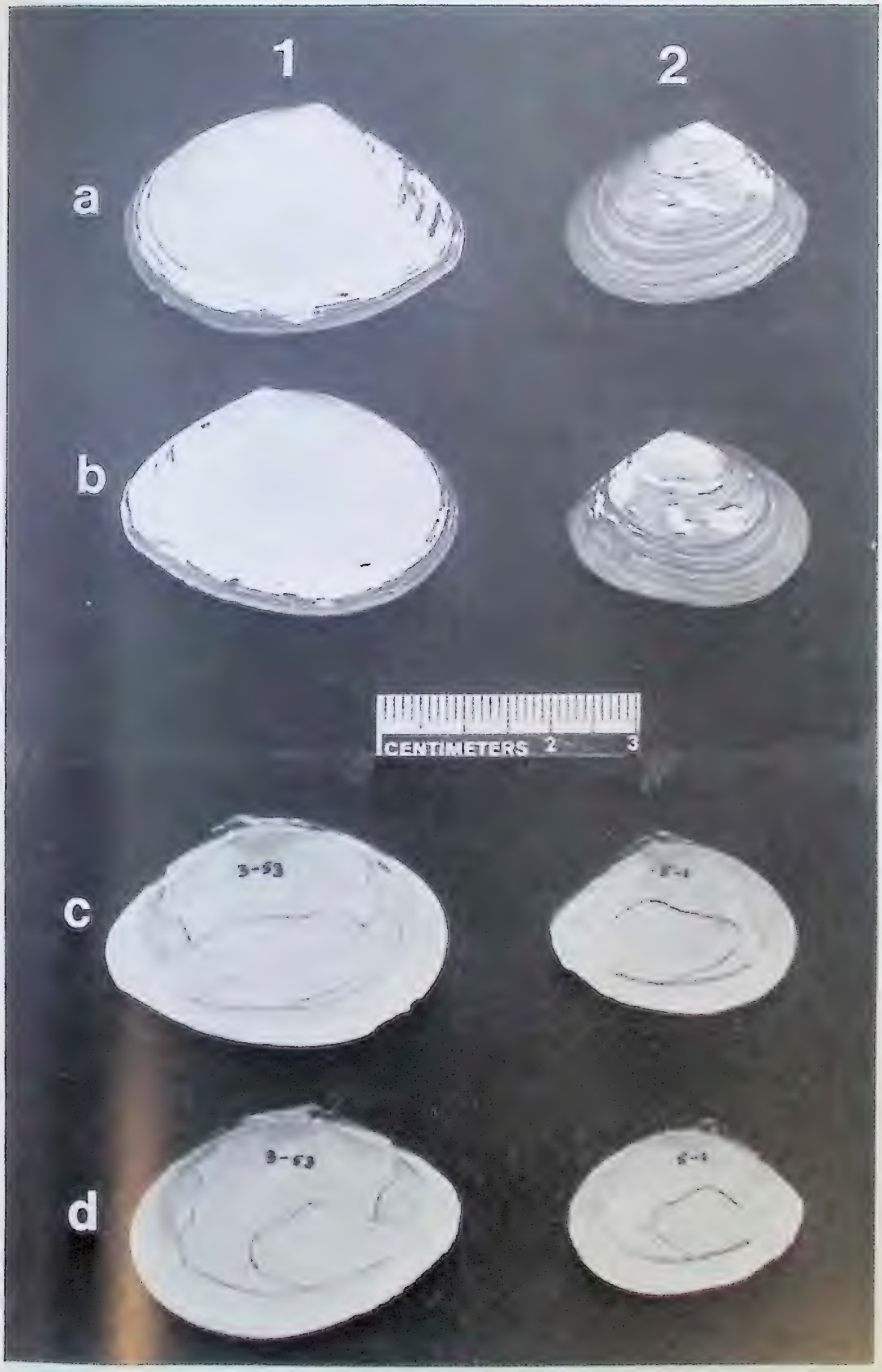

Figure 4 – 1a - d. *M. calcarea* (Gmelin)
2a - d. *M. elimata* Dunnill and Coan

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Moresby Island									
10 LV	3.02	2.17	0.88	1.71	2.39	0.72	0.29	0.57	0.79
RV	3.00	2.18		1.70	1.97	0.73		0.57	0.66
Gilford Island									
15 LV	3.88	2.69	1.10	2.17	3.03	0.69	0.29	0.56	0.78
RV	3.84	2.70		2.14	2.51	0.70		0.56	0.65
Bering Sea									
3 LV	5.65	4.00	1.79	3.24	4.33	0.71	0.32	0.57	0.77
RV	5.64	4.03		3.21	3.66	0.71		0.57	0.65

Size ranges were 1.56 - 4.65 centimetres for the specimens from British Columbia.

General Description – Figures 4, 1a - d; 9e

This circumboreal species reaches a large size in the Bering Sea area but is smaller to the south in British Columbia waters.

M. calcarea is moderately inflated, reaching its maximum thickness well anterior to the umbos. The umbos are situated about three-fifths of the way back from the anterior margin. The shell is ovate anteriorly, evenly arcuate ventrally but straight and sloping at the posterior dorsal margin until truncated, further back than in *M. brota.* Ornamentation consists of numerous fine, irregular concentric growth lines, strongest near the posterior margin. An oblique fold extends from the umbo to near the base of the posterior truncation in the right valve. The drab olive-green periostracum is much eroded in most specimens. The long narrow ligament is partially embedded and seated on a callus, much as in *M. brota.* There is a strong flexure to the right posteriorly.

Internally, the shell varies from porcellanous white to dark bluish-white. The pallial sinus in the left valve is long and relatively low, stopping just short of the anterior adductor scar, and is confluent with the pallial line in the area approximately beneath the umbos. The pallial sinus is shorter and relatively higher in the right valve than the left. Both pallial sinuses vary somewhat from one specimen to another. The dentition consists of two cardinal teeth in each valve, proportionately stouter in the right valve than the left. The left valve has a thin posterior cardinal on a wide base and a stouter bifid anterior cardinal. The right valve has strong anterior and posterior teeth, the latter bifid and expanding considerably from the stem.

There is considerable variation in shell outline within the *M. calcarea* population studied. More elongated specimens closely resemble *M. sitkana* Dall, and this is probably a synonym of *M. calcarea* (Dunnill and Coan, in press).

Unique Species Characteristics

M. calcarea (Gmelin) resembles *M. brota* Dall, *M. lipara* Dall, and *M. elimata* Dunnill and Coan but may be distinguished as follows:

M. elimata has an elongated flattened or slightly concave escutcheon, lacking in the other species.

M. calcarea is more elongate and more rostrate than *M. brota,* i.e. the ratio of height/length is less in *M. calcarea* than in *M. brota,* roughly 0.71 *cf.* 0.75.

M. brota is truncated posteriorly closer to the umbos than *M. calcarea,* giving *M. brota* a distinctively long, relatively straight, perpendicular posterior margin, equaling roughly one-third of the total length of the posterior margin from the umbo to the base of the posterior truncation.

M. calcarea is less inflated than *M. brota,* i.e. the ratio of thickness/length is less, roughly 0.29 *cf.* 0.33.

The umbos are small and relatively inconspicuous in *M. calcarea* but more prominent in *M. brota.*

M. lipara is more regularly ovate than *M. calcarea, M. brota,* and *M. elimata.*

Distribution and Habitat

Circumboreal, with type locality Iceland or the Faroe Islands. The range in the Pacific is 37 - 72°N and from 20 - 100 fathoms (Bernard 1967: 27). *M. calcarea* occurs from the Arctic Ocean to North Japan and "... from Greenland to Long Island Sound, 5 - 40 fathoms" (Burch 1946, No. 43: 11). Off Moresby Island, near Victoria, Vancouver Island, British Columbia, *M. calcarea* occurred from 15 to more than 40 fathoms in sediments ranging from sands to silty-sands and clayey-sands. It was very abundant at one location in a silty-sand from 44 fathoms (mean of 2 hauls = 226 specimens/metre^2) (Dunnill and Coan, in press).

Macoma carlottensis Whiteaves 1880, Rept. Prog. Geol. Surv. Can. 1879 - 1880, p. 196b.

Type Locality: Virago Sound, Queen Charlotte Islands, British Columbia.

Synonyms: M. inflatula Dall 1897 (Burch 1946, No. 43: 15).
M. quadrana Dall 1916.

Specimens Examined

8 from Satellite Channel, near Victoria, Vancouver Island, British Columbia, October 1966, 27 - 35 fathoms – UVIC.

5 from Blenkinsop Bay on Johnstone Strait, British Columbia, July 1885 – NMC 520.

8 from Mustang Bay, Hunter Island, British Columbia, June 1966 – FRB.

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Satellite Channel									
8 LV	1.55	1.10	0.59	0.88	1.21	0.71	0.38	0.57	0.78
RV	1.55	1.10		0.88	1.12	0.71		0.57	0.72
Blenkinsop Bay									
5 LV	1.45	0.99	0.51	0.82	1.14	0.68	0.35	0.57	0.79
RV	1.45	0.98		0.82	1.04	0.68		0.57	0.72
Mustang Bay									
8 LV	2.27	1.59	0.80	1.22	1.77	0.70	0.35	0.54	0.78
RV	2.27	1.58		1.22	1.62	0.70		0.54	0.71

General Description – Figures 6, 1a - d; 9k

This is one of the smaller west coast *Macoma* species. The largest specimen measured was a little less than 2.5 centimetres in length.

The shell is thin, fragile, and somewhat inflated, with maximum thickness anterior to the moderately prominent umbos. The anterior is evenly ovate, the posterior dorsal margin straighter and more steeply sloping from the umbos until finally truncated. The posterior ventral margin is slightly sinuous. The valves are inequilateral, the left valve deeper and more basin-like than the right. The umbos are situated in the posterior half of the shell. Sculpturing consists of fine concentric growth lines and an irregular fold extending from the umbos to the base of the posterior truncation. The shell is white with a low polish under a thin, flaky, green to brown or brownish-red periostracum. There is a strong flexure to the right, posteriorly. The ligament is thin, short, and inconspicuous.

The feebly polished interior is white and sometimes iridescent. The pallial sinuses are variable, high and moderately angular in some. The left valve has a slightly longer pallial sinus than the right. The dentition consists of two cardinal teeth in each valve. The left anterior and right posterior cardinals are stout, roughly triangular in cross section and moderately to fairly deeply grooved. The left posterior cardinal is very slender, but the right anterior cardinal is stouter and sometimes grooved.

Unique Species Characteristics

M. carlottensis is distinguished by the combination of small size, thin, fragile, moderately inflated valves, fairly prominent umbos, and tiny ligament.

Distribution and Habitat

According to Bernard (1967: 27), this species ranges from 27 - 72°N and from 15 - 100 fathoms. It was dredged from the north end of Moresby Island, near Victoria, Vancouver Island, British Columbia, in sands, clayey-sands, and silty-sands from 14 - 45 fathoms and from Sooke Basin, near Victoria, from black 'silt' at 10 fathoms.

Macoma elimata Dunnill and Coan (in press).

Type Locality: North end of Moresby Island, near Victoria, Vancouver Island, British Columbia.

Synonyms: M. calcarea (Gmelin), auctt., non *Tellina calcarea* Gmelin, 1791.

Specimens Examined

10 from Gilford Island, Queen Charlotte Strait, British Columbia, April 1966, 22 - 30 fathoms – FRB.

16 from north end of Moresby Island, near Victoria, Vancouver Island, British Columbia, October 1966, about 30 fathoms – RD.

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Gilford Island									
10 LV	3.04	2.20	1.06	1.81	2.34	0.72	0.35	0.60	0.77
RV	3.03	2.20		1.80	1.90	0.72		0.59	0.63
Moresby Island									
16 LV	2.98	2.18	0.98	1.73	2.32	0.73	0.33	0.58	0.78
RV	2.97	2.18		1.73	1.83	0.73		0.58	0.62

General Description – Figures 4, 2a - d; 9f

This is a medium sized *Macoma* species. The largest specimen of *M. elimata* found in the survey was 3.29 centimetres long. The shell is moderately inflated, reaching its maximum thickness well anterior to the umbos. The umbos are moderately prominent and raised slightly above the dorsal margin. The shell is ovate anteriorly, but posteriorly the dorsal margin is straight, sloping steeply down until truncated. The periostracum is drab grey-green, flaky, and usually not much eroded. Under the periostracum, the shell is chalky white. The shell is ornamented by fine concentric growth lines. The posterior dorsal margin has a conspicuous flattened or slightly concave escutcheon. The ligament is long and relatively narrow, standing above the flattened escutcheon. There is a slight flexure to the right posteriorly.

The interior is porcellanous white or bluish white, sometimes with a low polish and a silky lustre. The pallial sinuses are discrepant, long in the left valve (stopping just short of the anterior adductor scar) but much shorter and lower in the right valve. Both pallial sinuses loop back and are confluent with the pallial line in the area approximately beneath the umbos. The dentition consists of two cardinal teeth in each valve, the left anterior and right posterior bifid, the others laminar. The left posterior tooth is extremely fragile and frequently breaks off when the shell is opened.

Unique Species Characteristics

M. elimata resembles *M. caicarea* (Gmelin) but is smaller, plumper, relatively shorter posteriorly, and has a distinctive flattened or slightly concave, sharply incised escutcheon.

Distribution and Habitat

This species ranges from Ketchikan, Alaska to Redondo Beach, California, in 15 - 476 metres (Dunnill and Coan, in press). In the type locality, it is abundant in silty-sands, clayey-sands, and sand. It reached a density of 217 specimens/metre^2 at one station off Moresby Island, near Victoria, Vancouver Island, British Columbia, in 29 metres in clayey-sand. The mean density of two hauls at that station was 157 specimens/metre^2 (Dunnill and Coan, in press).

Macoma expansa Carpenter 1864, Suppl. Rep. Brit. Assoc. p. 639.

Type Locality: Puget Sound.

Specimens Examined

8 from Pachena Bay, Vancouver Island, British Columbia, August 1966, washed up on a sand beach – RD.

1 from Monterey, California – USNM 252213.

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Pachena Bay									
8 LV	4.47	3.17	1.38	2.13	3.42	0.71	0.31	0.48	0.77
RV	4.46	3.21		2.10	3.23	0.72		0.47	0.72
Monterey									
1 LV	3.19	2.18	0.91	1.50	2.50	0.69	0.29	0.47	0.78
RV	3.18	2.21		1.50	2.40	0.70		0.47	0.75

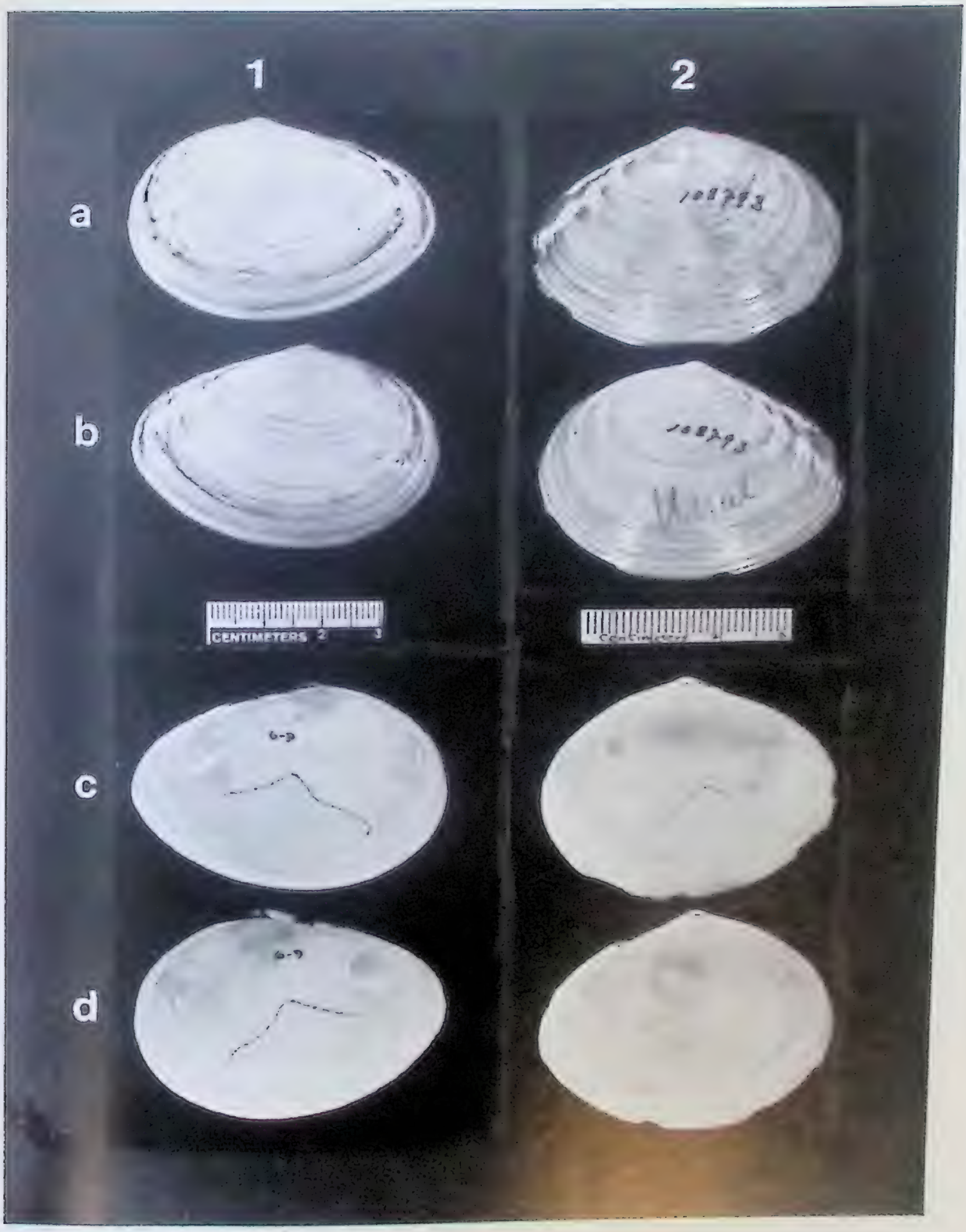

Figure 5 – 1a - d. *M. expansa* Carpenter
2a - d. *M. liotricha* Dall

General Description – Figures 5, 1a - d; 9g

The shell is moderately inflated and inequilateral, the anterior portion slightly shorter than the posterior. The anterior is ovate, the posterior somewhat rostrate and ending in a blunt point. The thin, glazed periostracum varies in colour from yellowy white to light yellowy brown or straw yellow and is commonly darker on the posterior dorsal margin. Thin but fairly strong, the shell is ornamented by fine concentric growth lines and an indistinct fold radiating from behind the umbos to the base of the dorsal posterior margin. There is a slight gape and a scarcely perceptible flexure to the right posteriorly. The right and left valves are more nearly mirror images than in many other species of *Macoma*. The short and narrow ligament is partially embedded and seated on a slender callus.

The interior is dull white with highly polished muscle scars. Faintly impressed, angular pallial sinuses are confluent with the pallial line almost at right angles, anterior to the umbos. The adductor scars have a tendency to be somewhat rectangular.

Unique Species Characteristics

M. expansa is distinguishable from most other *Macomas* by the combination of its more regularly ovate appearance, its glazed, often yellow tinted periostracum, its angular pallial sinuses confluent with the pallial line at nearly a right angle, and the tendency for both valves to look alike. It is close in these respects to *M. liotricha* Dall (Figure 5, 2a - d), but the only two specimens of the latter available for examination, from Capts Bay, Unalaska (USNM 108793), differ in being more equilateral and in sloping more quickly in front of the umbos. The two species seem closely related, and perhaps *liotricha* is a form of *expansa*.

Distribution and Habitat

According to Bernard (1967: 27 - 28), *M. expansa* occurs from 33 - 49°N and intertidally to 10 fathoms, and *M. liotricha* occurs from 49 - 56°N and intertidally to 5 fathoms. A number of specimens, of which eight were measured, were obtained from Pachena Bay on the west coast of Vancouver Island–a flat, shallow (almost entirely less than 10 fathoms), sandy bay, exposed to heavy wave action from the open Pacific Ocean. *M. expansa* is also found on Long Beach, to the north of Pachena Bay (D.B. Quayle, pers. comm.).

Macoma incongrua (von Martens) 1865, Ann. Mag. Nat. Hist. 16: 430.

Type Locality: Yokohama, Japan.

Specimens Examined

14 from southeast of Sidney Island, near Victoria, Vancouver Island, British Columbia, October 1966, 100 fathoms – RD.

10 from north end of Moresby Island, near Victoria, Vancouver Island, British Columbia, May 1967, 40 fathoms – RD.

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Sidney Island									
14 LV	1.90	1.59	0.78	1.15	1.53	0.84	0.41	0.60	0.81
RV	1.90	1.60		1.15	1.34	0.84		0.60	0.70
Moresby Island									
10 LV	2.96	2.43	1.23	1.61	2.42	0.82	0.42	0.54	0.82
RV	2.96	2.44		1.61	1.99	0.82		0.54	0.67

General Description – Figures 6, 2a - d; 9m

M. incongrua is small but strong, inflated and inequilateral, with prominent beaks situated about three-fifths of the distance from the anterior end. The anterior is evenly ovate, the posterior dorsal and ventral margins straight and sloping until truncated at about the mid-line. The shell is white and chalky or has a low polish under a grey or olive-green periostracum, commonly very much eroded, and is ornamented by irregular concentric growth lines. The shell gapes and has a slight flexure to the right posteriorly. The flexure makes the posterior extremity of the right valve sinuous.

The interior is dull or shiny white, sometimes with polished scars. In some the interior is iridescent. The pallial sinuses are long and high, that of the left valve reaching very nearly to the anterior adductor scar. Their confluence with the pallial line varies; generally in the right valve the pallial sinus loops posteriorly, but in the left valve it is sometimes confluent at a near right angle close to its anteriormost extension. The left anterior cardinal is bifid, long, and slender with little increase in thickness distally, while the left posterior tooth is feeble and usually breaks off when the shell is opened. The teeth of the right valve are stouter, the posterior cardinal is bifid and increasing in thickness distally, and the anterior cardinal is stout and pyramidal.

Unique Species Characteristics

M. incongrua somewhat resembles young *M. inquinata* (Deshayes) particularly the *arnheimi* variety, but differs in being more regularly rounded and, relatively, appreciably longer in the anterior portion. The shell is generally of coarser and chalkier texture in *M. inquinata.* The pallial sinuses of *M. incongrua* are higher and show more discrepancy between their lengths in the left and right valves. They are generally recurved posteriorly in *M. incongrua* only.

See also *M. inconspicua* (Broderip and Sowerby)

Note

Oldroyd's illustration of *M. incongrua* appears as *M. inquinata* (Oldroyd, 1924, pl. 42, fig. 10), but the illustration of *M. inquinata* (Deshayes) is shown as *M. incongrua* (same plate, fig. 9).

Distribution and Habitat

According to Bernard (1967: 27), this species occurs from 33 - 72°N and intertidally to 20 fathoms. However, he considers *M. inquinata arnheimi* Dall a synonym of *M. incongrua*. Specimens of *M. incongrua* were dredged off Sidney Island from 100 fathoms along with a mass of dead shells and fine 'shell-gravel.' North of Moresby Island, near Victoria, Vancouver Island, British Columbia, *M. incongrua* was obtained from 14 - 45 fathoms from 'shell-gravels,' sand, silty-sand, clayey-sand, and sand-silt-clay. It was frequently present in hauls from 'shell-gravel' associated with *Venerupsis kennerlyi* Carpenter, *Semele rubropicta* Dall, and *Yoldia myalis* Couthouy. In general, this was the only *Macoma* present in the 'shell-gravel.' *M. incongrua* was frequently absent in hauls away from 'shell-gravels,' yet it occurred in sediments of all types found in the sampled area at the north end of Moresby Island and reached a maximum size and density in a silt-sand-clay at 40 fathoms (151 specimens/metre^2).

Macoma inconspicua (Broderip and Sowerby) 1829, Zool. Journ., Vol. 4, p. 363.

Type Locality: Icy Cape, Alaska.

Synonyms: Possibly this is *M. balthica* (L). (Burch 1946, No. 43: 13), but see general description below.

Specimens Examined

10 from shallow channel on Mt. Douglas Park beach, near Victoria, Vancouver Island, British Columbia, February 1967 – RD.
9 from 'near Victoria,' British Columbia, 1885 – NMC 845.
6 (dead) from sand bar, near river bridge, Port Renfrew, Vancouver Island, British Columbia, October 1966 – RD.
3 from mouth of Stikine River, Alaska, June 1961 – NMC 19902.

General Description – Figures 6, 3a - d; 91

This is one of the smaller species of *Macoma*. The largest measured was just under an inch in length.

The shell is moderately inflated, with low umbos situated nearly midway between the anterior and posterior extremities. The anterior dorsal margin forms a shallow flat slope for a short distance from the umbo, then curves down smoothly, making the anterior half an almost perfect oval. The posterior dorsal margin slopes straight back until truncated. The shell is ornamented by fine concentric growth lines. The periostracum and the shell, particularly in the area of the umbos, was much eroded in many of the specimens examined. Shell colour varies from white to rose-red. The ligament, short but strong for the size of the shell, is partially sunken and seated on a fairly stout callus. There is a slight gape and an almost imperceptible flexure to the right posteriorly.

Internally, the colour varies from glazed white to rose-red. The pallial sinuses are roughly equal in both valves and are usually long, low, and somewhat angular. They generally are not greatly recurved and are confluent with the pallial line nearly at right angles. The dentition consists of two cardinal teeth in each valve; the

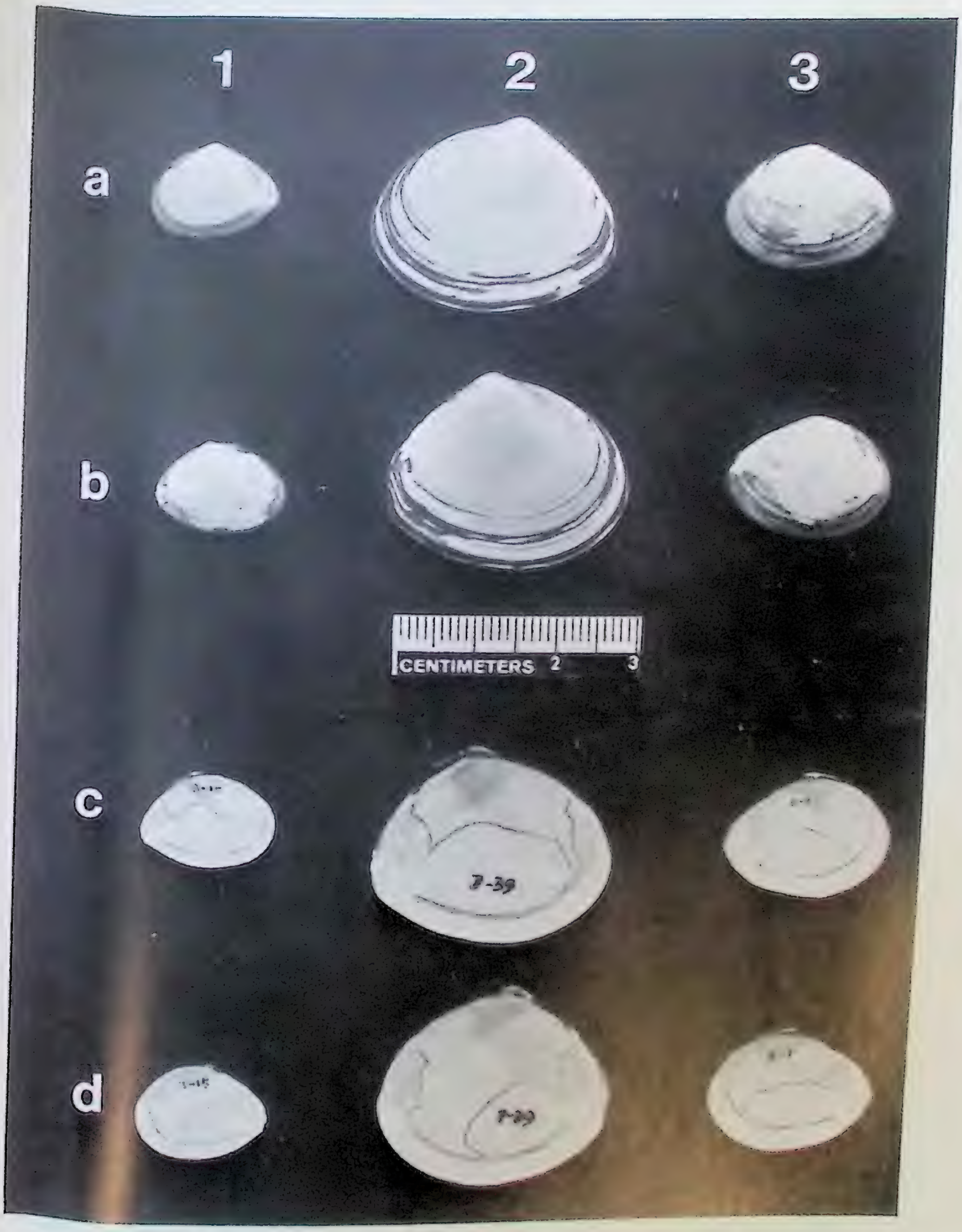

Figure 6 – 1a - d. *M. carlottensis* Whiteaves
2a - d. *M. incongrua* (von Martens)
3a - d. *M. inconspicua* (Broderip and Sowerby)

left anterior and right posterior teeth are expanded at the apex and bifid; the others are laminar and more slender.

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Mt. Douglas Park									
10 LV	1.44	1.12	0.51	0.73	1.13	0.78	0.35	0.51	0.79
RV	1.45	1.12		0.73	1.16	0.77		0.50	0.80
'near Victoria'									
9 LV	1.85	1.47	0.68	0.92	1.46	0.79	0.37	0.50	0.79
RV	1.85	1.48		0.91	1.46	0.80		0.49	0.79
Port Renfrew									
6 LV	1.98	1.68	0.82	1.06	1.52	0.85	0.41	0.54	0.77
RV	1.99	1.70		1.07	1.55	0.85		0.54	0.78
Stikine R.									
3 LV	2.06	1.60	0.80	0.98	1.62	0.78	0.39	0.48	0.79
RV	2.06	1.60		0.97	1.64	0.78		0.47	0.80

This Pacific species is listed in Dall (1921) as *M. balthica* (L.), but Burch (Burch 1946, No. 43: 13) and Keen (*in* Burch, ibid.) are of the opinion that the west coast form is sufficiently different from the Atlantic *M. balthica* to warrant its own specific name. There is considerable variation in the shape and appearance of *M. inconspicua* from place to place and within populations on the west coast.

Unique Species Characteristics

M. inconspicua is somewhat like *M. incongrua* (von Martens) and may possibly resemble juvenile of other species. The umbos of *M. inconspicua* are frequently much eroded and are less prominent than those of *M. incongrua*. The rose colour of some specimens of *M. inconspicua* assists in identification. The combination of low glazed periostracum, roughly equal pallial sinuses confluent with the pallial line near their anteriormost extent, low, centrally-situated umbos, prominent ligament, and scarcely perceptible posterior flexure should be adequate to distinguish this species from others.

Distribution and Habitat

M. inconspicua ranges from the Arctic Ocean to San Diego, California (Quayle 1960). The Mt. Doublas Park specimens were screened from the top five

centimetres of a shallow, water-filled channel on a 'sandy' beach. The Port Renfrew specimens were washed up on a sand bar in a generally sandy area. According to Quayle (1960), the species occurs in sheltered waters in "sandy-mud" bottom and is generally distributed in British Columbia. At Rock Bay, near Kelsey Bay, Vancouver Island, specimens were observed buried 4 - 5 centimetres deep, on a coarse sandy beach, with their longitudinal axes almost vertical and the posterior margin uppermost. Two cylindrical holes for the siphons remained open in the sediment, extending from the posterior shell margin to within a centimetre of the surface even when the siphons were retracted.

Macoma inquinata (Deshayes), 1854, Proc. Zool. Soc., p. 357.

Type Locality: Vancouver Island, British Columbia.
Synonym: M. inquinata arnheimi Dall, 1916.

Specimens Examined

14 from Sooke. Vancouver Island, British Columbia – NMC 1049.
6 from Shelter Bay, Nanaimo, Vancouver Island, British Columbia, intertidal – FRB.

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Sooke									
14 LV	3.44	2.59	1.35	1.51	2.88	0.75	0.39	0.44	0.84
RV	3.44	2.59		1.51	2.83	0.75		0.44	0.82
Shelter Bay									
6 LV	4.20	3.14	1.60	1.79	3.48	0.75	0.38	0.43	0.83
RV	4.21	3.14		1.79	3.35	0.75		0.43	0.80

General Description – Figures 7, 1a - d, 2a - d; 9d

M. inquinata is inequilateral, moderately inflated, and has a relatively strong shell. The posterior is rostrate. The dorsal margin slopes convexly, the ventral margin rises to meet it, and both end in a blunt point. The shell is chalky white under a drab olive-green periostracum, much of which has flaked off in large specimens. The beaks are prosogyrate and fairly prominent. Ornamentation consists of irregular concentric growth lines and a fold extending obliquely posteriorly from the umbos. The ligament is long, narrow, strong, and prominent. There is a slight gape and flexure to the right, posteriorly.

Interiorly, the shell is porcellanous white and feebly polished, except for the adductor scars and pallial grooves, which are glossy. The pallial sinuses are long and almost equal, reaching in the left valve very nearly to the anterior adductor and with little or no recurving. The two cardinal teeth in each valve are fairly strong and have a low angle of divergence.

Two extremes of form, one noticeably plumper and less rostrate than the other, were obtained from the same beach area. The short, plump specimens may be Dall's *arnheimi* "variety" (figure 8), but a range of intermediate forms occurs also.

Unique Species Characteristics

M. inquinata resembles *M. nasuta* but can be distinguished easily, since only in *nasuta* does the pallial sinus of the left valve reach and join the anterior adductor scar well above its base.

M. incongrua is similar to young specimens of *M. inquinata,* but the former is more rotund and generally has higher pallial sinuses with greater discrepancy between them in the two valves.

Distribution and Habitat

M. inquinata is described as occurring from Bering Strait to Japan on the west to Terminal Island, San Pedro, California, on the east and found usually in soft "muddy sand" (Burch 1946, No. 43: 12). At Mill Bay, near Victoria, Vancouver Island, British Columbia, many specimens of the *arnheimi* variety of *M. inquinata* were obtained intertidally from 'coarse sand' containing a high proportion of shell fragments. Specimens of the elongate variety were found in 'sand' intertidally at Mt. Douglas Park, near Victoria, Vancouver Island, British Columbia. Distorted specimens were obtained from thin layers of fine sediment, overlying flat rocks about 1 foot in diameter, on the beach of Ker Island, near Sidney, Vancouver Island, British Columbia. In places, these shells were so densely packed, they were 'standing' on their anterior ends and almost touching one another.

Macoma lipara Dall 1916, Proc. U.S. Nat. Mus. 52: 414.

Type Locality: Bering Strait, Alaska.

Specimens Examined

9 from Narvaez Bay, Saturna Island, Strait of Georgia, British Columbia, October 1966, about 100 fathoms, sand – RD.

37 from Gilford Island, Queen Charlotte Strait, British Columbia, April 1966, 22 - 30 fathoms – FRB.

Lengths of specimens measured range from 4.65 - 5.56 centimetres for intact specimens from Narvaez Bay (one odd right valve is 7.31 centimetres) and 3.60 - 5.99 centimetres for those from Gilford Island.

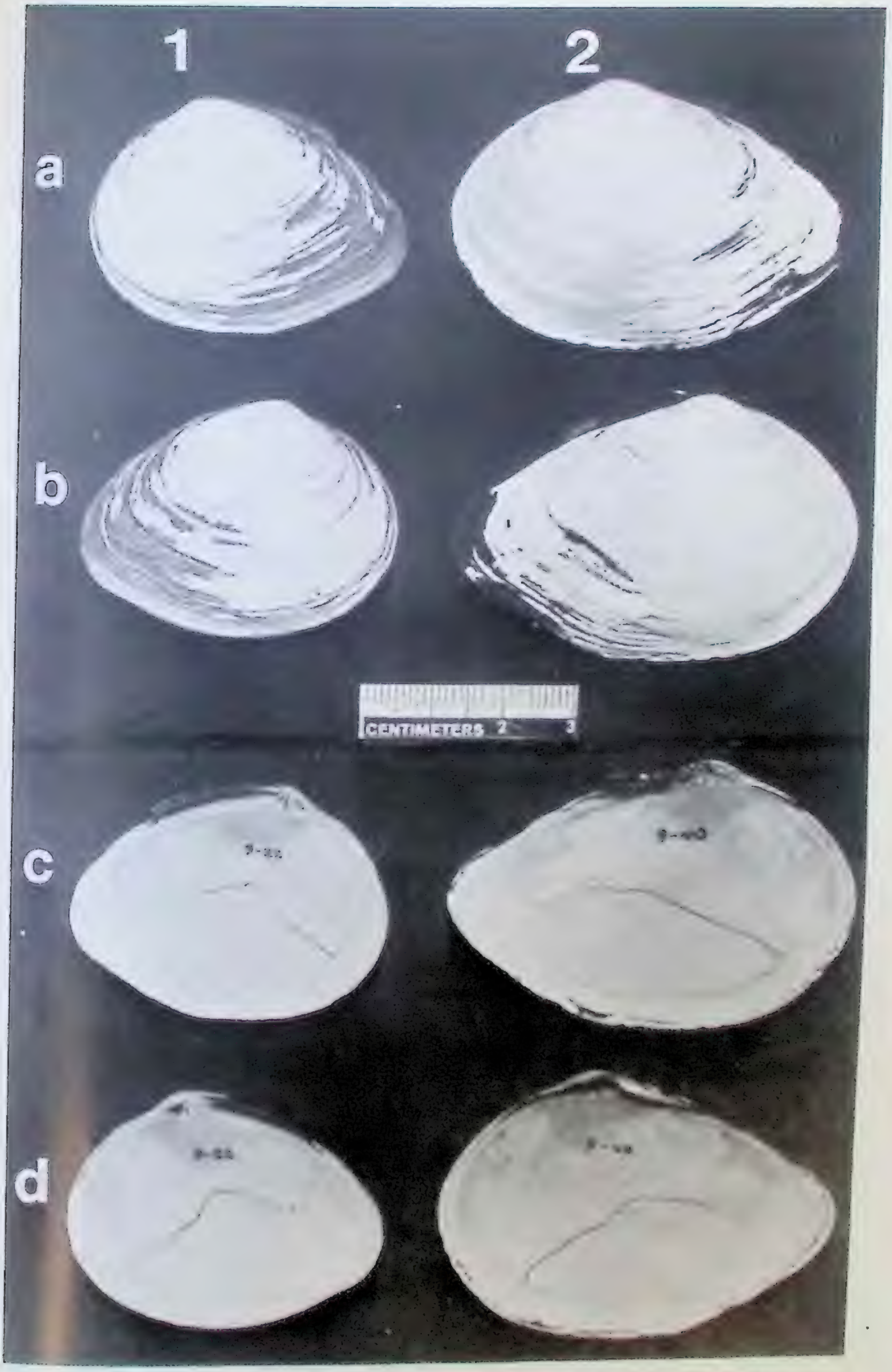

Figure 7 – 1a - d. *M. inquinata* (Deshayes) (short 'variety,' *M. inquinata arnheimi* Dall)
2a - d. *M. inquinata* (Deshayes) (elongate form)

Measurements

Size (cm)	No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
Narvaez Bay										
3.00 - 5.00	6 LV	4.79	3.70	1.48	2.66	3.40	0.77	0.31	0.56	0.71
	RV	4.79	3.70		2.66	2.94	0.77		0.56	0.61
5.00 - 7.00	3 LV	5.41	4.33	1.82	2.98	3.86	0.80	0.34	0.55	0.71
	RV	5.43	4.34		2.98	3.29	0.80		0.55	0.61
Gilford Island										
3.00 - 5.00	10 LV	4.39	3.37	1.27	2.45	3.14	0.77	0.29	0.56	0.71
	RV	4.39	3.38		2.45	2.71	0.77		0.56	0.62
5.00 - 7.00	27 LV	5.63	4.44	1.78	3.06	4.04	0.79	0.32	0.54	0.72
	RV	5.63	4.45		3.06	3.45	0.79		0.54	0.61

General Description — Figures 3, 1a - d; 9b

M. lipara is one of the largest of North American west coast *Macoma* species. The valves are stout and moderately inflated, with fairly prominent umbos situated between half and three-fifths of the distance back from the anteriormost extremity. The anterior portion of the shell is more regularly ovate than the posterior portion. Shells from different areas vary in thickness. The Gilford Island specimens had thinner and lighter coloured shells than those from Georgia Strait. The periostracum varies from olive-green to grey but frequently is almost completely eroded. The shell varies from white to straw yellow and is usually shiny. Ornamentation consists of fine, closely spaced, sharply etched, concentric growth lines and a fold extending posteriorly and downward from the umbos. There is a fairly strong flexure to the right at the posterior end.

The interior is porcellanous white or bluish-white with a low polish. The pallial sinuses are fairly high and confluent with the pallial line well back from their anteriormost extension. The pallial sinus is longer in the left valve than in the right. The right posterior and left anterior cardinal teeth are bifid, the others laminar. The laminar teeth tend to break off, when the valves are opened.

Unique Species Characteristics

M. lipara was originally described as a variety of *M. brota* Dall. However, *M. lipara* is more ovate and lacks the broad perpendicular truncation characteristic of *M. brota.* The periostracum of *M. lipara* is generally greatly eroded, more so than in *M. brota.* The shell of *M. lipara* is usually shiny, while that of *M. brota* is dull and chalky. *M. lipara* is a larger species than *M. brota* in southern British Columbia.

Distribution and Habitat

Bernard (1967: 27) considers *M. lipara* a synonym of *M. brota* Dall and gives *M. brota* a range from 48 - 64°N and from 30 - 80 fathoms. Dall, in his original description, said *M. lipara* did not extend as far north as *M. brota.* Off Moresby Island, near Victoria, Vancouver Island, British Columbia, *M. lipara* was dredged from 16 - 46 fathoms in sand, clayey-sand, silty-sand, and sand-silt-clay. It occurred in maximum density (23 specimens/metre^2) in sand-silt-clay at 40 fathoms. It was also dredged from 100 fathoms south of Sidney Island, near Victoria, Vancouver Island, British Columbia.

Macoma nasuta Conrad (1837), Journ. Acad. Nat. Sci. Phil. 7: 258.

Type Locality: Near San Diego, California.
Synonym: M. kelseyi Dall, 1900 (Burch 1946, No. 43: 14).

Specimens Examined

12 from Sooke Basin, near Victoria, Vancouver Island, British Columbia, November 1966, 10 fathoms – RD.

7 from Mt. Douglas Park beach, near Victoria, Vancouver Island, British Columbia, September 1966, intertidal – RD.

1 from Shelter Bay, Nanaimo, Vancouver Island, British Columbia, intertidal – FRB.

1 from Skidegate, Queen Charlotte Islands, British Columbia – NMC 1558.

Measurements

Size (cm)	No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
1.00 - 3.00	9 LV	1.89	1.33	0.60	1.00	1.61	0.70	0.32	0.53	0.85
	RV	1.88	1.31		1.00	1.58	0.70		0.53	0.84
3.00 - 5.00	7 LV	4.11	2.91	1.24	2.10	3.41	0.71	0.30	0.51	0.83
	RV	4.07	2.90		2.08	3.17	0.71		0.51	0.78
5.00 - 7.00	5 LV	6.25	4.34	1.80	3.06	5.37	0.69	0.29	0.49	0.86
	RV	6.18	4.35		3.03	5.19	0.70		0.49	0.84

General Description – Figures 8, 1a - d; 9h

One of the larger west coast *Macoma* species, *M. nasuta* reaches a length of more than three inches.

M. nasuta is compressed and fairly thin for its size, with an ovate anterior and a cuneate posterior portion. The shell is feebly polished and white under a thin, dark greenish-grey periostracum. Ornamentation consists of fine concentric growth lines and an oblique fold sloping from the beak to near the junction of the posterior truncation and the ventral margin. The ventral margin is asymmetrically arcuate.

The posterior dorsal margin is straight and slopes down from the umbos until truncated just anterior to where it would have met the rising posterior ventral margin. The slightly prominent umbos are close to the centre line making the anterior and posterior halves of the shell about equal in length. The ligament is long, narrow, and strong. There is a pronounced flexure to the right, posteriorly.

The interior is lightly polished and porcellanous. The pallial sinus reaches the anterior adductor scar in the left valve but is shorter in the right. Each valve has two cardinal teeth, the left anterior and the right posterior are bifid, the others are thin and feeble, especially the one in the left valve. The teeth are all thinner near the base, increasing in thickness distally.

Unique Species Characteristics

The pallial sinus in the left valve of *M. nasuta* extends to and joins with the anterior adductor scar well above its base. A fossil form, *M. kelseyi* Dall, was described as closely related to *M. nasuta* (Conrad), but larger, heavier, and flatter. Since the pallial sinus in the left valve of *M. kelseyi* also reaches and joins with the anterior adductor scar, well above its base, *M. kelseyi* is probably a large variety of *M. nasuta.* Grant and Gale made it a subspecies of *M. nasuta,* calling it *M. nasuta kelseyi* Dall (Burch 1946, No. 43: 14).

Distribution and Habitat

According to Bernard (1967: 28), *M. nasuta* occurs from 28 - 60°N and intertidally to 40 fathoms. Burch (1946, No. 43: 11) states that it favours "fine mud" in protected areas and penetrates brackish water. In Sooke Basin it occurs in a soft black silt. However, it is not restricted to fine sediments. *M. nasuta* occurs in 'sand' at Miracle Beach, Vancouver Island, British Columbia and has been found washed up on sandy beaches, e.g. Pachena Bay on the west coast of Vancouver Island and Sidney Spit, Sidney Island, near Victoria, British Columbia.

Macoma secta (Conrad) 1837, Journ. Acad. Sci. Phil. 7: 257.

Type Locality: San Diego, California.
Specimens Examined

6 from Mt. Douglas Park, near Victoria, Vancouver Island, British Columbia, intertidal, December 15th, 1967 – RD.

6 from Weir's beach, near Victoria, Vancouver Island, British Columbia, December 18th, 1967 – RD.

Measurements

No. specimens	L	H	B	A	Sp	H/L	B/L	A/L	Sp/L
12 LV	6.67	5.28	2.26	3.14	4.97	0.79	0.34	0.45	0.74
RV	6.76	5.45		3.33	5.00	0.80	0.33	0.49	0.74

Specimens measured ranged from 4.53 - 8.50 centimetres in length.

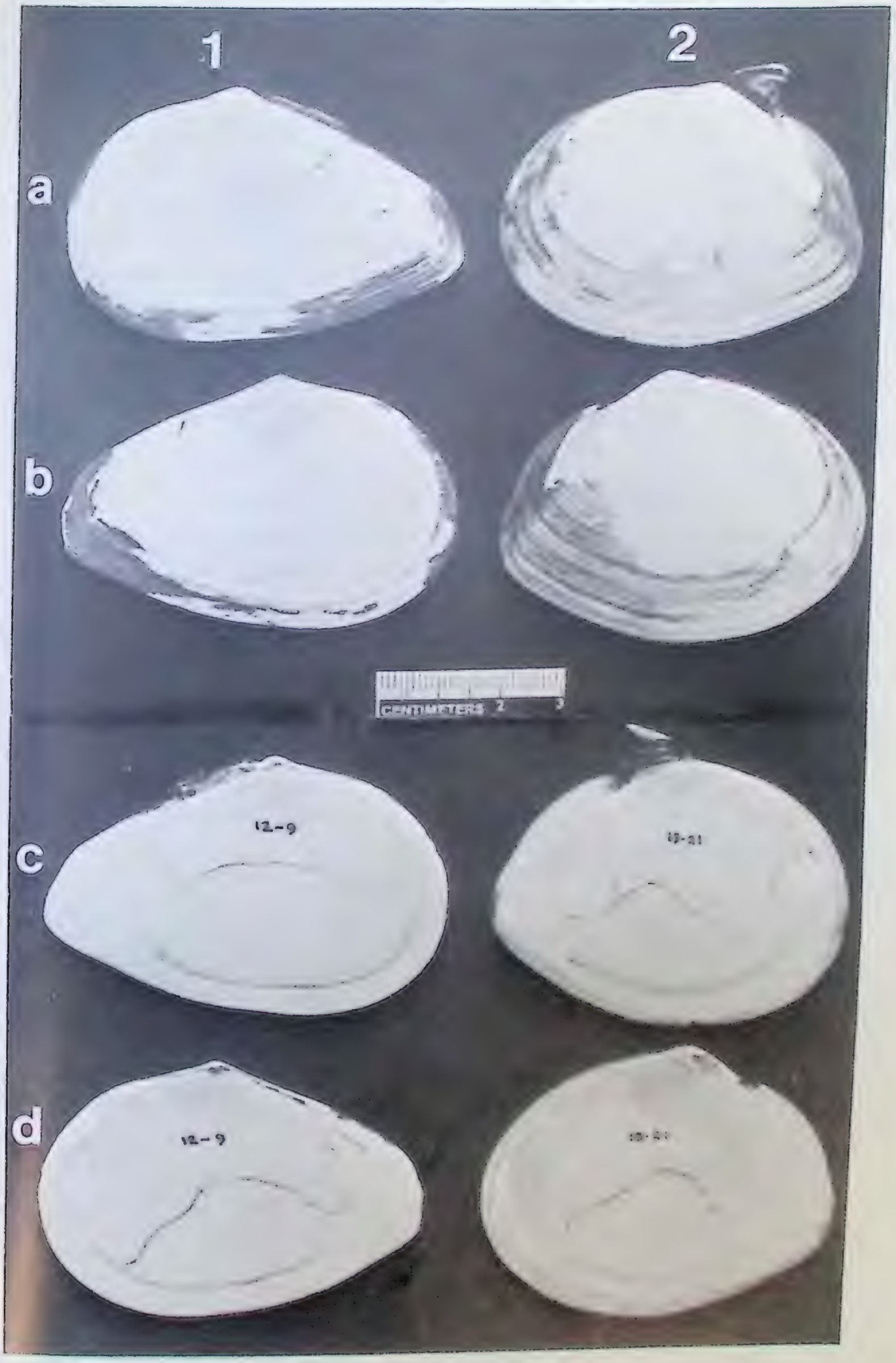

Figure 8 – 1a - d. *M. nasuta* (Conrad)
2a - d. *M. secta* (Conrad)

General Description – Figures 8, 2a - d; 9c

M. secta is one of the largest of North American west coast *Macoma* species. The creamy-white shell is sub-elliptical, compressed, and thin for its size. It is overlain by a thin, polished, white or straw-yellow periostracum, commonly darker and having a fibrous appearance at the posterior margin. The periostracum is frequently much eroded in larger specimens. The anterior is larger than the posterior portion and evenly ovate, while the posterior margin is broadly and obliquely truncated. The ventral margin is arcuate and rises to meet the posterior truncation in a blunt point at the postero-ventral extremity of a fold radiating from the umbo. The left valve is shorter, less high, and flatter than the right valve. The short, noticeably broad ligament is seated on an elongated rib-like callus, which continues on the inside surface well past the end of the ligament and cleaves the top of the posterior adductor scar. The valves gape and are slightly flexed to the right. posteriorly.

The interior is white and the scars and ventral margins polished. The somewhat angular pallial sinuses are slightly recurved and are confluent with the pallial line well anterior to the umbos. The inside surfaces may show one or more shallow grooves and low rounded ridges radiating from the umbos. There are two cardinal teeth in each valve. The left anterior and right posterior cardinals are stout and bifid, the others laminar and more delicate.

Unique Species Characteristics

M. secta can be distinguished from other *Macoma* species in that it is one of the largest species of the genus, it possesses a short, noticeably broad, rounded ligament set in a notch in the dorsal profile, the left valve is flattened while the right is somewhat inflated, and it is one of the few species of *Macoma* approaching its size to have a glazed periostracum.

Distribution and Habitat

According to Bernard (1967: 29), *M. secta* occurs between latitude 23 - 55°N and intertidally to 20 fathoms. The species occurs down to 25 fathoms off Redondo Beach, California, and is "too common to list localities on the west coast" (Burch 1946, No. 43: 16). It is very common on some sandy beaches near Victoria, Vancouver Island, British Columbia, where it generally burrows down to about 18 inches. In shallow channels uncovered by the tide, it may sometimes be found only 1 or 2 inches down.

Dall distinguished between a "large and small variety," stating the typical larger variety lives in the open sea and is generally more northern in its distribution than the smaller, sheltered water variety (Burch 1946, No. 43: 16).

Macoma yoldiformis Carpenter 1864, Rept. Brit. Assoc. Adv. Sci. for 1863, p. 630.

Type Locality: Not yet fixed.

Specimens Examined

10 from Skidegate, Queen Charlotte Islands, British Columbia – NMC 1561.

5 from Sooke Basin, near Victoria, Vancouver Island, British Columbia, November 1966, 12 fathoms – UVIC.

Measurements

No. specimens	L	H	B	A	H/L	B/L	A/L
Skidegate							
10 LV	1.30	0.75	0.34	0.84	0.58	0.26	0.65
RV	1.29	0.75		0.84	0.58		0.65
Sooke							
5 LV	1.90	1.14	0.53	1.18	0.60	0.28	0.62
RV	1.89	1.15		1.18	0.60		0.62

Individual lengths ranged from 0.91 - 1.81 centimetres for the Skidegate specimens and from 1.75 - 2.09 centimetres for those from Sooke.

General Description — Figures 2, 1a - d; 9j

M. yoldiformis, one of the smaller west coast *Macoma* species, reaches a length of a little less than one inch. It is inequilateral (the anterior about twice as long as the posterior) and somewhat compressed, about a quarter as thick as long. The fragile white shell has a thin, translucent, glazed periostracum except at the posterior margin, where it becomes opaque and grey-brown. The beaks are somewhat less prominent than in *M. alaskana.* The margin of the anterior portion of the shell forms a deep 'U,' while the posterior forms a shallower 'V.' The ligament lies in a shallow concavity or notch behind the umbos. The remainder of the posterior dorsal margin curves downward, until it meets the steeply rising curve of the ventral margin at about the midpoint. There is some variance in the degree of roundness posteriorly.

The interior is white and polished with somewhat variable pallial sinuses, which are often high and angular and slightly longer in the left valve. The two cardinal teeth in the right valve are both fairly stout, although only the posterior tooth is bifid. Those in the right valve are feebler, the anterior slightly grooved and the posterior so fragile it usually breaks off when the shell is opened.

Unique Species Characteristics

M. yoldiformis is sometimes confused with *Tellina modesta* Carpenter, with which *T. buttoni* Dall may be synonymous (Abbott 1954: 425). However, the latter has "a well-formed radial rib just behind the anterior muscle scar" (Abbott 1954: 425), and the ventral margin rises very little posteriorly, making the posterior margin wedge-shaped rather than rounded as in *M. yoldiformis.* The pallial sinuses are lower and much longer in *T. modesta,* and this form has lateral teeth which are lacking in *Macoma. M. yoldiformis* resembles *M. alaskana* in some ways, but the posterior portion of the latter is wedge-shaped.

Distribution and Habitat

According to Bernard (1967: 29) *M. yoldiformis* occurs from 33 - 56°N and intertidally to 10 fathoms. In Sooke Basin, it occurs down to 12 fathoms in black 'silt.' It is also described (Burch 1946, No. 43: 15) as having been found down to 25 fathoms near Monterey, California, in "shale and mud" and "in 15 - 25 fathoms 'gravel and sand,' common off Redondo Beach, California." It has been obtained only sparingly by dredging in Sooke Basin, but a 0.1 m^2 Van Veen grab brought up two specimens in two grabs suggesting it may be more numerous than the dredging indicates. It occurs on the north side of Moresby Island, near Victoria, Vancouver Island, British Columbia, in 14 fathoms in clayey-sand and, sparingly, in Nanoose Harbour, Vancouver Island.

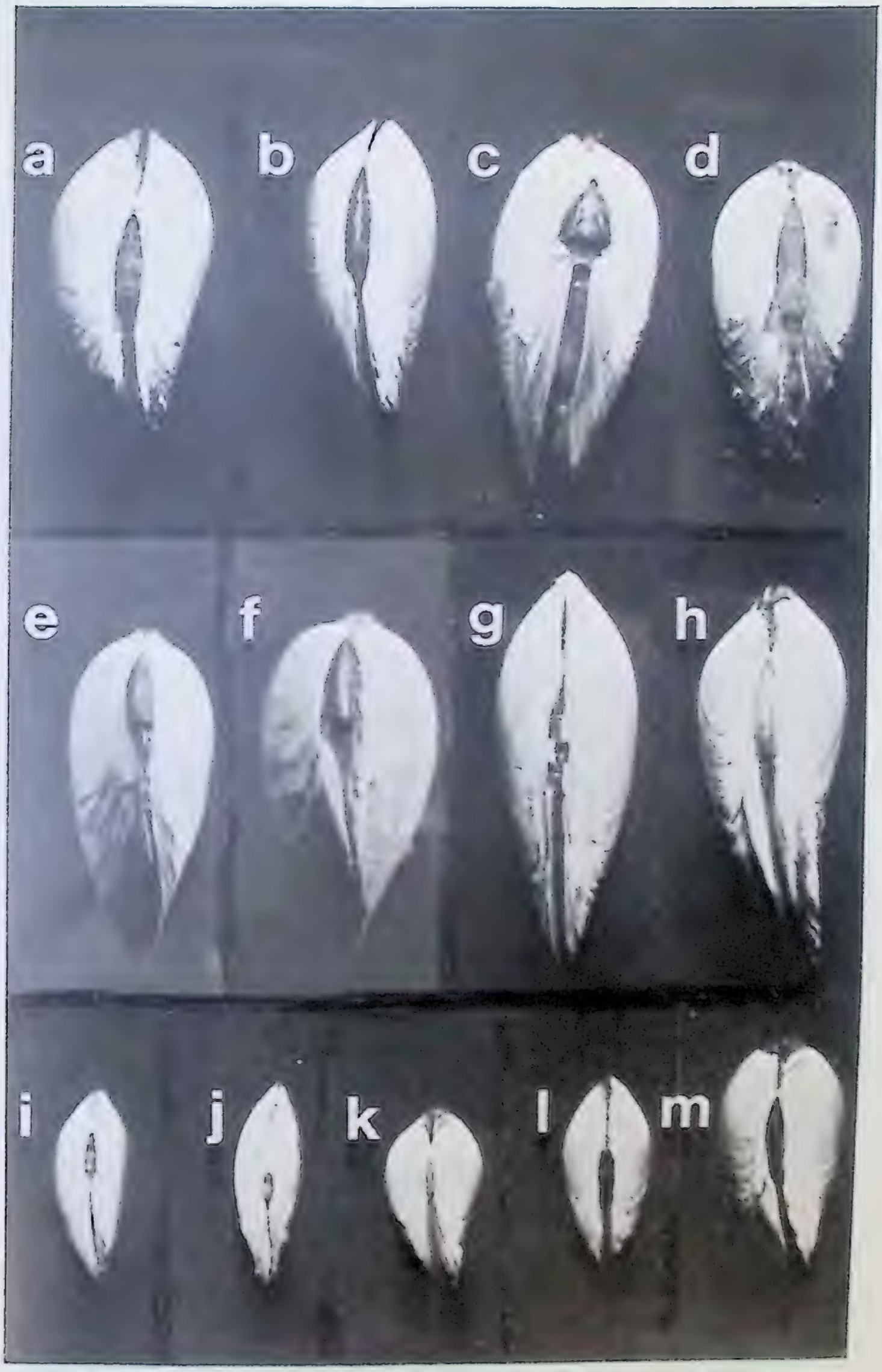

Figure 9 – Hinges of the 13 species found in the investigation

a. *M. brota* Dall
b. *M. lipara* Dall
c. *M. secta* (Conrad)
d. *M. inquinata* (Deshayes)
e. *M. calcarea* (Gmelin)
f. *M. elimata* Dunnill and Coan
g. *M. expansa* Carpenter
h. *M. nasuta* (Conrad)
i. *M. alaskana* Dall
j. *M. yoldiformis* Carpenter
k. *M. carlottensis* Whiteaves
l. *M. inconspicua* (Broderip and Sowerby)
m. *M. incongrua* (von Martens)

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